TRANSMISSION LINE LOUDSPEAKER PROJECT INSIDE

electronics today

AUGUST 1977 INTERNATIONAL

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$1·25*
NZ $1.50

741 COOKBOOK

TRUE RMS VOLTMETER
FOR ANY WAVEFORM

GAS ALARM
DETECTS PETROL VAPOUR

INSIDE VCT
CIRCUIT ANALYSED

INSTALLING ALARMS
AND OTHER SAFEGUARDS

WHY YOUR NEXT CASSETTE SHOULD BE A MAXELL UD

1 THE RESEARCH — More than twenty years ago, Maxell produced their first reel of magnetic tape. At that time, Maxell made a commitment to produce and sell only the finest magnetic products their technology could create.

That commitment still stands today.

2 THE TAPE — This continuous research has lead to the development of the Maxell UD (ultra dynamic) cassette. A tape that has a coating of super-fine PX gamma ferric oxide particles with an extra smooth mirror-finish surface.

All of this adds up to high output, low noise, distortion free performance and a dynamic range equaling that of open reel tapes.

3 THE SHELL — Even the best tape can get mangled in a poorly constructed shell. That's why Maxell protects its tape with a precisely constructed shell, made of lasting heavy-duty plastic.

No fixed guide posts are used. Instead Maxell uses nylon rollers on stainless steel pins thus eliminating the major cause of skipping, jumping and unwinding.

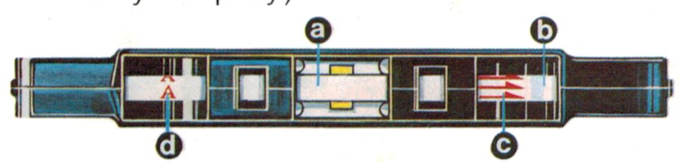
A tough teflon (not waxed paper) slip sheet keeps the tape pack tight and flat. No more bent or nicked tape to ruin your recording.

Maxell doesn't use a welded seal, but puts the cassette together with precision screws. Result — Maxell doesn't jam.

ULTRA-DYNAMIC
UD

4 THE LEADER — A leader tape that has a four function purpose.

a) Non-abrasive head cleaning leader (cleans recording head for 5 secs.).
b) 5 second cueing line (recording function starts 5 seconds after the line appears).
c) Arrows indicating direction of tape travel.
d) A/B side mark (indicates which side is ready for play).



Now you know why your next cassette should be a Maxell UD (ultra dynamic).

maxell®

The sound expert's cassette. UD available in C60, C90 and C120.
Distributed by **Hagemeyer (Australasia) B.V.** Branches in all States.

WT GD 127M

AUSTRALIAN OWNED AND PRODUCED *AUGUST 1977 Vol.7 No.8*

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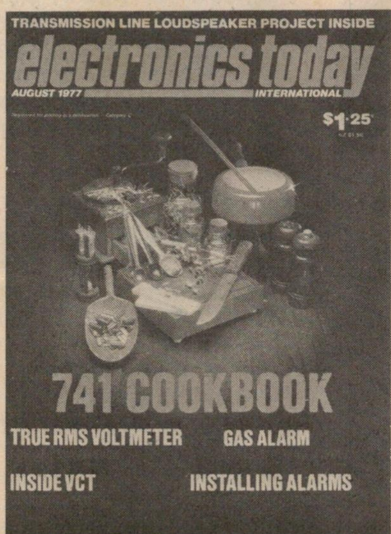


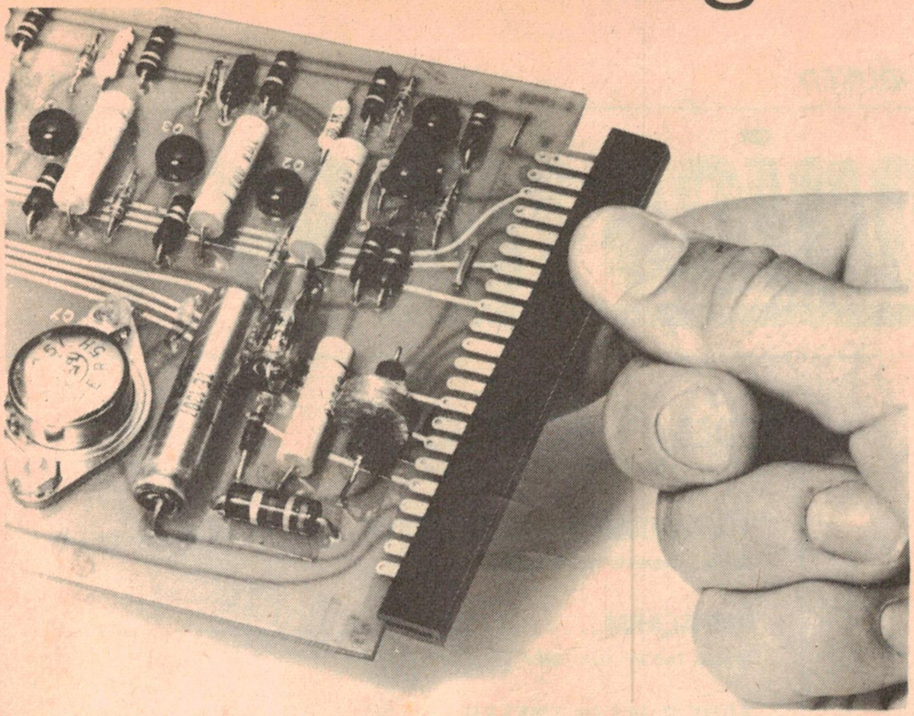
Cover: Doesn't that make your mouth water! Our cover this month was shot by Toronto (Canada) photographer Christopher Darling, for the Canadian edition of ETI. It's a photographer's view of our 741 Cookbook article, which is also being published by the British and Australian editions. Apologies also go to Sydney photographer George Hofsteters, whose excellent work (uncredited) adorns last months cover. Incidentally, it was shot on a 1920 bellows camera, just to point up the good old days of photography!

A Modern Magazines Publication
* Recomended retail price only.

PROJECTS

FEATURES

NEWS & INFORMATION



SUPERBOARDSHORTS

Static electricity is frequently created by high speed dry air. This is a common occurrence in burn-in ovens, and in flow soldering operations where warm air is used to remove moisture from the surface prior to flow soldering.

A new conductive high temperature elastomeric edge connector that slides over P.C. board fingers to short all tabs together and equalize static charge has been developed. Designed for 150°C ambient applications, it will also withstand 300°C (500°F) flow solder temperature without degradation.

Boardshorts of a standard length of 8" are available from *Royston Electronics, 22 Firth Street, Doncaster, Victoria, 3108.*

DIP SWITCHES

DYS Series duel-in-line switches have "piano key" type actuators to provide easy operation and convenient viewing of switch status. Designed for card-edge mounting on printed circuit boards, DYS switches are available in SPST (4 to 10 stations) and SPDT (2 to 5 station) to accommodate a variety of circuit programming needs. Contacts are gold plated for long, reliable service life in low energy circuits, and all terminals are sealed to prevent solder and flux wicking. Rocker and slide versions are also available. For further information contact: *Namco Electronics 239 Bay Street, North Brighton 3186.*

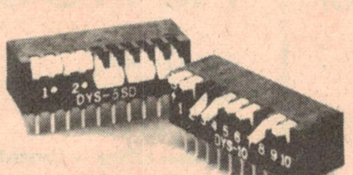
TRANSDUCER READOUT

Schaevitz Engineering expand their range of transducer readouts with a fully self contained digital indicator. Connection to an LVDT type transducer and AC power line resutls in a complete measurement package at low cost.

The 3½ digit readout occupies 8 square inches of panel space and reads out directly in engineering units. BCD output is standard. By designing signal conditioning and readout as an integral system, high accuracy is achieved. Overall linearity is ± o.1% of full scale ± 1 count. Choice of low transducer excitation voltage minimises thermal drift and other inaccuracies due to transducer heat up.

Recommended applications include gauging, digital weighing, pressure indication and general laboratory use in conjunction with displacement, force weight and pressure transducers.

Further information obtainable from J.W. Ralton at *Applied Measurement Australia Pty. Ltd., Box 172, Glen Iris. Victoria 3146.*



JOINT MISSION?

NASA and the USSR Academy of Sciences have started discussions on a joint Space Shuttle/Salyut Space Station programme for the early 1980s. Three joint working groups have been established to study scientific and applications studies to be tackled, the problems of co-operation and the possibility of constructing an international space station or platform.

THE MARS CUP

Very much in the news at the moment is the America's Cup race for sailing yachts, but in a few years, we may well see a new version of the sport. NASA are proposing to build a solar sail-powered spacecraft to investigate Halley's Comet in 1986. The heliogyro would use centrifugal force to spin out 12 aluminized plastic sails which would then carry the spacecraft along in the solar 'wind'. The craft, which would rotate once every three minutes, would be launched by the Space Shuttle, and is the brainchild of two southern California aerospace engineers.

The heliogyro will compete with a proposed ion drive propulsion system for NASA approval; a ½ mile square sail is now out of the running.

TV STUDY CARREL

A Television Study Carrel for use by Visually Impaired students has been developed by Mr. D. T. Harison of the RVIB School for Blind Children. The device enables semi-blind people to obtain instant large print for study and reference purposes. The book to be read is placed face down on a glass plate let into a desk top. A television camera with zoom lens and close up attachments is mounted under the desk and views the book via a 45° mirror. The display is seen on a TV monitor, conveniently located over the desk. Negative-positive switching is provided for use where glare is a problem. The size of the print is controlled by the zoom lens. Care has been taken to make the unit as simple as possible. No refocusing is required for books of different thickness because the focal plane is the top of the desk. There is room for a portable typewriter and tape recorder to be used on the desk whilst the book is being read. Seven of these units are now in use in the school andone has already been bought by one of our students.

Details from Royal Victorian Institute for the Blind, 557 St. Kilda Road, Melbourne, Vic. 3004.

TELEX TAPE BITS

To meet the increasing demand for heavy duty tape components in Education, Broadcasting and Data Logging, Telex USA have added to their range of cartridge and reel type components with the introduction of their model RP85 record replay amplifier.

The Model RP85 is a single channel record/play amplifier for professional quality magnetic tape recording with the Telex models 36 continuous cartridge deck, or 230 heavy duty open reel tape transport. The RP85 can also be used with other type of NAB cartridge or open reel transports.

Telex tape components are available in Australia from *Audio Telex Communications Pty Ltd at 54 Alfred Street Milsons Point.*

MOSTEK 4K STATIC

The Mostek Mk4104 is a high performance static random access memory organised as 4096 one bit words. The MK4104 combines the best characteristics of static and dynamic memory techniques to achieve a TTL compatible, 5 volt only, high performance, low power memory device. It utilizes advanced circuit design concepts and an innovative state-of-the-art N-channel silicon gate process specially tailored to provide static data storage with the performance (speed and power) of dynamic RAMs. Since the storage is all static the device may be stopped indefinitely with the CE clock in the off (logic 1) state.

The MK 4104 family has access times of 200, 250 and 300 ns and average power dissipation less than 120mW. Standby power dissipation is less than 28mW. For further information contact: *Namce Electronics 239 Bay Street, North Brighton 3186.*

Also from Namco, a one-board microcomputer called the SDB-80 is supplied with 16 kilobytes of random-access memory. Built round the Z-80 microprocessor family, the Software Development Board may also be purchased with a complete package of system firmware, which is contained in five on-board 2-kilobyte read-only memories. This firmware package allows the user to generate, edit, assemble, execute, and debug Z-80 programs.

Because the development software is contained in the ROMs all of the RAM space is available for user programs.

PAGING SYSTEM

AN ELECTRONIC paging system incorporating integrated circuit design and a capacity of 180 units is available from Intercept Communications Pty Ltd.

The 'Intercept 180' system uses a tone-tone encoded sequence to contact each receiver. Any number of separate receivers to a maximum of 180 can be called from one base unit.

When the operator keys the number of the called unit, it is visually displayed on the three-digit LED readout so that the operator can check the number before pressing the call button.

The call button sends out the coded signal to the receiver. One-way voice transmission may then be sent by the operator. A special 'speak now' light indicates when to start speaking.

CMOS ingegrated circuits are used throughout for low power consumption and reliability to ensure long life. All electronic parts are standard to reduce maintenance costs.

For greater accuracy, code tones are synthesised by phase-locked loop circuits.

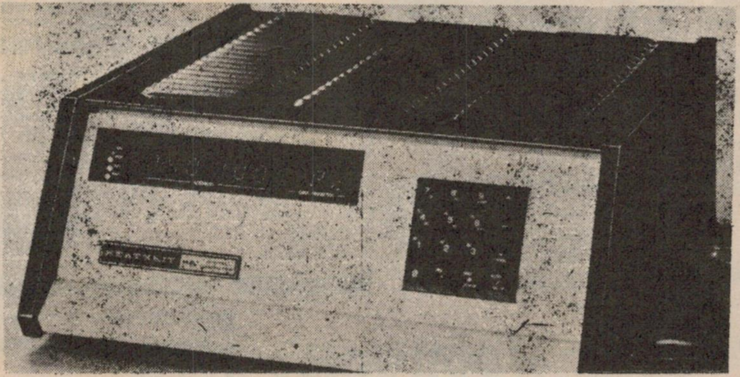
The unit can be programmed on site to incorporate alterations or additions, without being returned to the company's workshop. Additional to the 180 individual calls, automatic group calls can be made to up to 20 groups of nine.

Where more than one encoder is installed, a 'busy' light indicates when another unit is being used.

The receivers wiegh 110 grams (3.8 ounces) and measure 88 mm by 49 mm by 188 mm (3.5 in by 1.9 in by 0.7 in).

They are economical to operate. Battery life in excess of 3000 hours is calimed.

Intercept Communications, Suites 4, 5 & 6, Morr Arcade, 600 Burke Road, Camberwell, Vic 3126.



Heathkit's new H8 computer *(see p.7)*

CB's

10% DISCOUNT

TO ALL CB CLUB MEMBERS

on all CB RIGS and ACCESSORIES upon presentation of membership card.

* SPECIALS EXCLUDED!

SIDEWINDER III $99.50

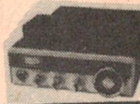
De-luxe AM 23ch, features mic gain, RF gain, delta-tune, ANL, S/PWR meter, PA-CB switch, guaranteed top model RRP $145

* SPECIAL

SUPER PANTHER $249

by Pearce-Simpson

Scoop purchase of top-quality SSB rig — limited quantities at this super low price.



* SPECIAL

SEMICONDUCTOR SPECIALS

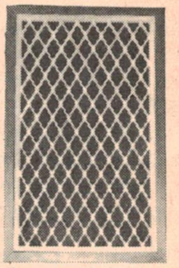
BC107	15c
BC108	15c
BC109	15c
TT800	75c
TT801	75c
2N3643	30c
1N914	10c
OA91	12c
EM401-4	10c
A14A 2.5A	20c
5023 RED LED	25c
5023 GRN LED	50c
MAN7 display	$1.75
6.8V 5W zener	50c
2N3055 80V	$1.00
7400	20c
7441	$1.00
7473	70c
7490	70c
600PIV 25A rect.	75c

Originals or equivalents supplied!

KITS *You can build 'em yourself – a great way to learn the "state of the art".*

500W Light Dimmer C/W wall mtg plate	$6.95
Motor Speed Control suits most motors, fans, etc.	$5.50
9 Transistor Car Radio — push-button, 12V neg grd, Philips Tuned RF front-end, last few only	$18.00
P/M 145 8 Input Mixer — also 4 input stereo, C/W base, treble, vol, master vol, VU's, etc.	$115.00
FM Radio Antenna — dipole gives up to 6dB gain	$11.50
2 Transistor Radio — for beginners, works well, only	$4.50
100W Power Amplifier ETI 413 — ideal guitar, PA	$69.50
4 Input Pre-Amp ETI 419 — suit above ETI 413	$9.50
Ignition Suppressor — for car radio interference	$2.50
Variwiper — adjustable windscreen wiper control	$10.00
Dual LED Flasher — burglar deterrent for cars, etc.	$2.95
Mag. Pre-Amp — stereo, for mag cart, 300mV out	$9.00
30V 2A Reg Supply — for amps, experiments, etc. C/W trans.	$10.00
Power Supply ETI 111 — 1.5 to 15V DC at 1.5A variable	$19.50
Temperature Meter ETI 113 — 0 to 200°C in 3 ranges	$49.00
Kemstar Tuner — Wideband hi-fi AM tuner	$45.00
Musicolour II — Popular colour organ 3KW	$55.00
4 Input Mixer — General purpose mixer	$18.00
Stereo Pre-Amp — Switch — 3 inputs, 2 indep. switches	$4.50
Digital Stopwatch ETI 520 — Versatile, accurate	$70.00
Experimenters Workshop ETI — tools, parts, ICs, etc.	$115.00

SPEAKER KITS



Partly assembled universal speaker box kits, below normal price, beautifully made by our cabinet factory. With "continental-look" WOOD GRILLE FRONTS, you mount speakers, front, back and wire up etc — it's so easy to DO IT YOURSELF. You'll have a really professional job and you'll save $$$. Walnut finish.

SPK-15 $22 EA.
SIZE 570 x 330 x 230 mm. Suits all 10" and smaller speakers

SPK-10 $20 EA.
Suits all 8" and smaller speakers

SPK-5 $16 EA.
Size 435 x 275 x 230 mm. Suits all 8" and smaller speakers.

FANTASTIC BOOK REDUCTIONS!

Japanese Transistor Manual. Over 30,000 transistor specifications and base connections on 167 pages, lists all the transistors registered with the Electronic Industries Association of Japan. **Was $3.95, now only $3 ea.**

World Transistor Cross-Reference Guide. Extensive listings (over 50,000) of European-American-Japanese transistors with specifications and equivalents. Every serviceman should have one. **Reduced from $7.50 to only $5.00.**

STOCK-TAKING ☆ ☆ ☆ ☆ SPECIALS ☆ ☆ ☆ ☆

500 ½w resistors $3.00; 100 1w resistors $1.00; 40 5w, 10w resistors $3.00; 50 hi-stab ½ per cent, 1 per cent, 2 per cent asst. resistors $1.50; 100 asst capacitors, cer, poly, mica 100-630V $2.00; 20 new, quality asst potentiometers $2.00; 50 asst tagstrips $2.00; 10 asst switches, toggle, DPDT, rotary, slide etc $2.00; 200 asst nuts, bolts etc $100' 25 TTL asst, ICs, new $4.50; 50 asst RTLIC's, new $5.00; 100 asst RTLIC's, new $9.00; 30 PVC insulated mains terminal blocks $1.00; 10 alligator clip jumper leads asst colours $2.00; 30 lengths 6" x asst sizes and colours spaghetti $1.50; 80 way PC edge connector, you cut to own size $1.00; Heat sensor cut-out switch, for transformers, heatsinks etc 50c; 10 pces PCB offcuts, some fibreglass, 2-sided etc $2.00.

INTEGRATED CIRCUITS TTL

7400	45c	7447	$1.95
7401	45c	7450	50
7402	45c	7453	50
7403	45c	7460	50
7404	45c	7473	$1.00
7406	$1.20	7476	$1.10
7407	$1.20	7483	$1.80
7408	50	7490	$1.00
7409	50	7491	$1.40
7410	50	7493	$1.10
7411	50	74100	$1.00
7412	80	74107	$1.00
7413	$1.30	74141	$3.20
7416	$1.00	74145	$1.00
7420	50	74151	$1.00
7427	$1.00	74154	$3.45
7430	45	74164	$3.50
7432	80c	74181	$1.00
7440	50c	74182	$1.00
7441	$1.50		
7442	$1.30		

Also CMOS, linear, etc.

TEST EQUIPMENT SALE! SALE!

A large variety of good, used test gear for sale at bargain prices to personal shoppers only — mostly laboratory equipment e.g. Fluke 332 Voltage Standard, HP 140 Oscilloscope, Fairchild PULSE Generators, Beckmann Function Generators etc.

CB RADIO at best prices

SWR METER ANTENNA MATCHER JD-175

Tune your aerial for really low SWR and maximum power output with this 3-in-1 combo. Normal price $32.50. SPECIAL PRICE

SWR, POWER, FIELD STRENGTH METER 110

Comprehensive, multi-purpose test set and in-line SWR BRIDGE, 52 ohms, 1:1 to 1:3, power 0-10, 0-100w. Normal price $27.50

CB ANTENNAE

5' Helical Whip, roof or boot mount	$22.00
Base-loaded whip	$19.00
As above, magnet mtg.	$19.95
CB/AM/FM combo centre-loaded whip	$30.00
Twin Truckers dual mirror mtg. aerials	$37.70
SWR meter, in-line	$19.50
PL-259 plugs	$1 ea.
RG58/V Cable, per mtr.	45c

Large range of CB accessories ex stock.

"HARD-TO-GET" AND MISCELLANEOUS ITEMS

PCB etch resist pens	$1.50	75-300 ohm balun	$2.00
NIXIE tubes, 0-9, GR111	$1.00 ea	300-75 ohm balun	$2.00
NE-2 neons 60V oper.	10c	4XUM-3 batt holder	30c
T0-3 mtg ins. bushes	50 for 50c	3/8" ferrite rods	25c
1.5uF 35V tantalums	15c	Car aerials	$2.50
PVC-2 tuning gangs	50c	ON-OFF toggle switch	40c
3.5mm earphone plugs	10c	DPDT toggle switch	55c
3.5mm sockets	10c	DPDT rotary switch	65c
Fuseholders, in-line 3AG	15c	DPDT slide switch	30c
5K Trans vol. controls.	35c	3PDT rocker switch	60c
Knobs to suit, 33mm diam.	10c	HT suppressors 15K	35c
Mag. earpieces, 3.5mm plug	30c	MA1002B NS clock	$12.00
Cigar lighter plugs	30c	Transformer to suit	$6.00
240 neon bezels	50c	5 pin din plug	30c
Car aerial sockets	5c	9 lug tagstrips	10 for 30c
Alligator clips	10c	16 way plug/socket	$1.00
TK-64 white knobs	15c	50 ohm 2W WW pots	50c
TK-55 brown knobs	15c	Permeability tuners	$1.00
TK-29 black knobs	15c	Mono cartridges	$1.00
TK-816 alum. knobs	30c	Stereo cartridges C-1	$3.00
70 x 45mm oval spkr 8 ohm	$1.55	6" x 4" speakers	$2.00
58mm diam. spkr 25 ohm	$1.20	UM-3 Ni-cad batts	$1.65
8 track cartridges	$1.20		

Originals or equivalents supplied.

SPEAKERS, ETC.

Coral
Complete kits with Xovers, etc.

85A1 15W RMS	$49
10SA1 25W RMS	$75
12SA1 30W RMS	$109

Cabinets available to suit

Car Speakers — dual imp.

5" diam. 4.8 ohm	$5.50
7" x 5" 4,8 ohm	$5.95
8" x 4" 4,8 ohm	$6.95
9" x 6" 4,8 ohm	$7.50

Crossovers

2 WAY 30W	$3.50
3 WAY 40W	$6.95

Hi-Fi Woofers

12" 30W 8 ohm	$29.90
10" 25W 8 ohm	$21.75
8" 15W 8 ohm	$10.50
8" Twin cone	$11.90

Mid-Range

5" 30W 8 ohm	$5.45
51/4" 20W 8 ohm	$3.50

Tweeters

Dome 20W 8 ohm	$8.95
Dome 50W 8 ohm	$11.00
Cone 21/2" 8 ohm	$1.95
Cone 3" 8 ohm	$4.80
Horn	$9.95

HV POWER SUPPLIES

0-500V at up to 250mA, used but good working order, also 0-250V 50mA neg. output for bias control plus 6.3V 10A AC output. To clear to bargain prices, personal shoppers only, $30 ea.

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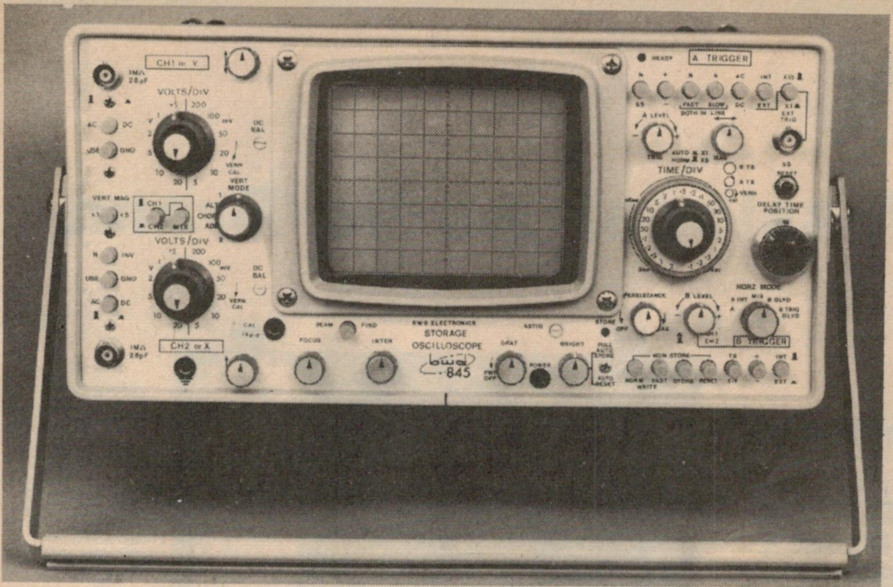


NEW BWD INSTRUMENTS

Four new instruments will be highlighted on the BWD stand at the I.R.E.E. CON in August; two are oscilloscopes, one is a new version of the unique MINI-LAB, and the fourth a function generator.

BWD's wide range of Australian designed and manufactured oscilloscopes has now been extended into the storage field with the new BWD 845 dual trace variable persistence storage model (above). It is a versatile portable instrument providing 30 MHz bandwidth, 1 mV sensitivity on both amplifiers and dual time bases with mixed, delayed or delayed trigger capability. Storage speeds extend to 1 cm/µsec and both auto store and auto view facilities are provided.

Another new oscilloscope to be displayed is the BWD 539D. This version of the very popular 539 Series has a sensitivity of 5 mV/cm to 20 V/cm on both channels and bandwidth is now DC to 25 MHz. In the single channel cascade mode, sensitivity is increased to 500µV/cm with a 12 Hz to 100 kHz bandwidth. Triggering extends to 30 MHz, and it has a very stable video sync separator which also doubles as a demodulator for AM signals.

One of the most successful instruments in the BWD range is the multi-function MINI-LAB. A new version of this model, the BWD 603B is on display. Its function generator frequency reange extends from 0.001 Hz to 2 MHz and is available as a sine, square or triangle, ramp, pulse which can be AM and/or FM modulated and now had an inbuilt ramp generator to sweep it over two decades. The variable frequency and amplitude sweep ramp can be amplified or inverted to drive other circuits including the horizontal sweep of an oscilloscope or recorder by the wide band amplifier/op amp. The power amplifier can be switched to bipolar power supply of ±15 V at 1 amp or to a fixed +5 V 1 amp supply. Other outputs are ±1 to 15 V 1 amp supplies, 0-200 V 35 mA and a 6.3-0-6.3 VAC supply. The instrument conforms closely to IEC 348 recommendations.

The new BWD 160A function generator has a 0.02 Hz to 2 MHz range and 10 V p-p output into a 50 Ω load or 20 V p-p open circuit. A two step 40 dB attenuator and vernier control can reduce this down to the millivolt level. The output can be swept over 4 decades by an external ramp from the companion instrument the BWD 170. A separate TTL output will drive up to 20TTL loads. The three basic waveforms, sine, square and triangle, are available on the rear panel at 1V p-p levels.

BWD Electronics Pty Ltd, PO Box 325, Springval, Vic. 3171.

Voice-Controlled Wheelchair

Two researchers at the University of California at Santa Barbera have developed a voice-controlled wheelchair, which should enormously help patients with paralysis of both the upper and lower parts of their bodies. The wheelchair is only slightly affected by extraneous noise, and understands eight commands.

Sinclair Programmable Offer (July 1977)

We understand that the Sinclair Cambridge Programmable calculator offered to readers last month is now available elsewhere at the same price if bought as a package of calculator, library and mains adapter.

Because of this readers ordering the calculator via ETI should omit the $2.50 postage charge referred to in the offer.

Readers who have already sent us cheques will receive a rebate directly from ETI.

We apologize to readers for this error.

COWBUGS

An electronic livestock identification system under development by the US Livestock Conservation Institute will both identify an animal and give its body temperature, which is a great improvement over the old method of taking its temperature. An implant transponder under the animal's skin will respond to the interrogation of a small plastic gun which reads the animal's ID number and temperature.

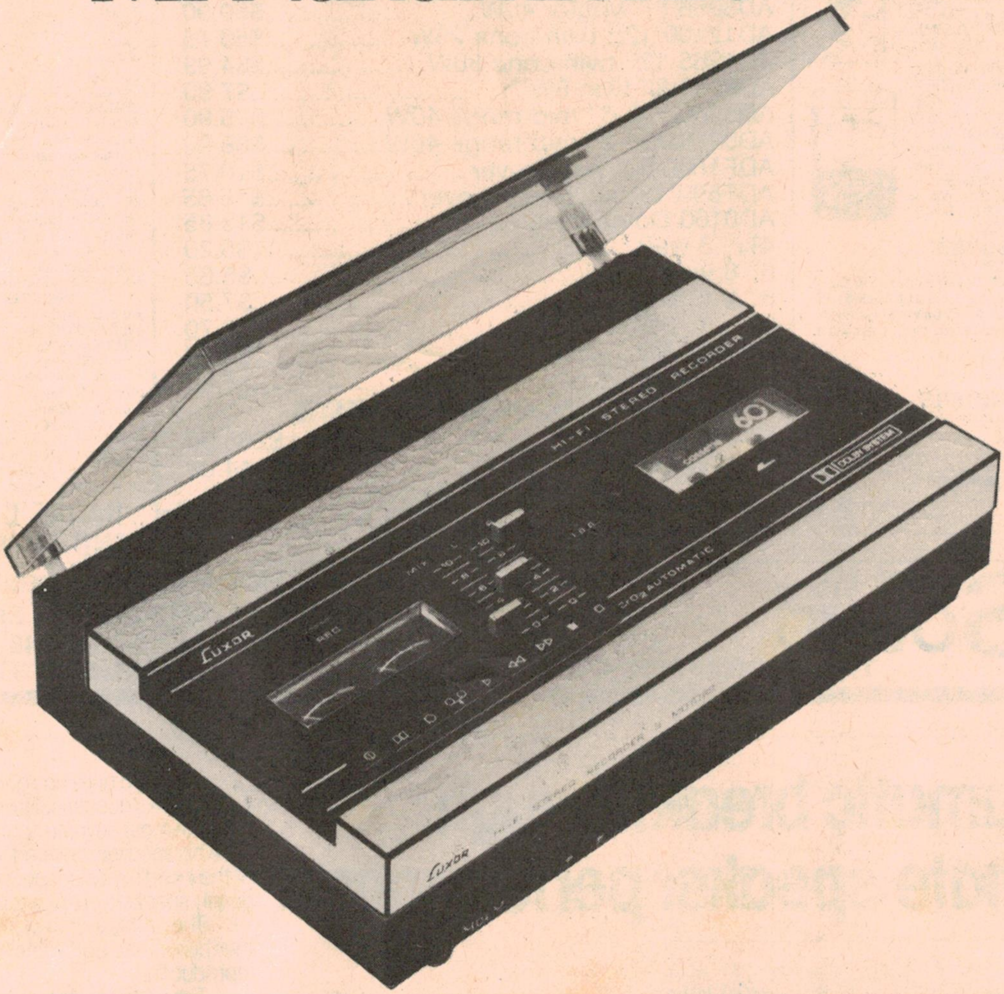
Calculator Contest

The winner of the June ETI/Unitrex calculator competition was Mr. N. Wickramasinghe, of Narre Warren North, Victoria. The best way to arrange the bills in the hats is to put a single $2 bill in one hat, and the 10 $2 bills plus the remaining 9 $2 bills in the other. If the statistician selects the first hat, he is certain to pick a $2 bill; if he goes for the second, the probability is 9/19 that he will draw a two-dollar bill. Therefore, the probability that he will choose the first hat and a $2 bill is ½ x 1 or ½. The probability of choosing the second hat and then choosing a $2 bill is ½ x 9/19 or 9/38. The overall probability of getting a $2 bill is the sum of these probabilities, i.e., 14/19.

This month's problem concerns an Indian, who, canoeing upstream, accidentally drops one of his paddles. He doesn't realise this until ten minutes later. At that time, he turns around and paddles downstream (at the same rate relative to the stream), and catches up with the paddle one mile from the place he dropped it. What is the rate of flow of the stream?

Send your answer on the back of an empty envelope (don't forget to add your name and address) and send it to: Unitrex Calculator Contest (August), ETI Magazine, 15 Boundary Street, Rushcutters Bay, NSW 2011. Closing date is September 16th.

A cassette deck to break Mr Nakamichi's heart.



Make / Model	S/N dB NR out Fe	S/N dB NR out Cr	S/N dB NR in Fe	S/N dB NR in Cr	Wow and flutter % DIN weighted	Signal levels mV IN Mic	Signal levels mV IN Line	Signal levels mV OUT Line	Fast winding sec. C60 cassette	Meter	Built-in mixer	Deviation from nominal tape speed	Automatic Fe/CrO_2 switching	FeCr capability	Noise-reduction System DNL	Noise-reduction System Dolby	Output volume control	Tape memory	B=Illuminated cassette	Signal Connectors
Luxor 9255	52	55	59	61	0,045	0,20	9	610	37	VU	Yes	±0	Yes	Yes	No	Yes	No	No	B	DIN
Nakamichi 600	52	55	60	61	0,07	—	65	750	111	P	No	+1,2	No	No	No	Yes	Yes	Yes	—	DIN+Phono

(from Stereo HiFi No. 5, 1976)

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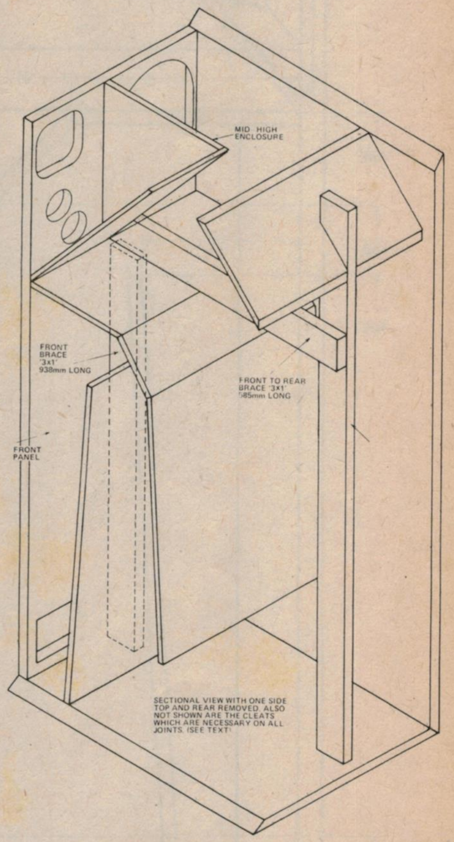
LUX0989/R

TRANSMISSION LINE SPEAKERS

These transmission line speakers have been designed and progressively developed by audio consultant Richard Timmins. In their final form they have been used as reference speakers by our sister publication Hi-Fi Review.



IN MANY respects transmission line speakers are an attempt to utilise the benefits of infinite baffle speaker enclosures but without the latter's inherent drawbacks — particularly that of restricted bass response.

Theoretically, transmission line speakers are essentially non-resonant over the entire low frequency register. In practice the need to fold the 'line' can introduce resonances and therefore colouration in the upper-bass and lower mid-range though these may be designed out by suitable techniques which are described later in this article.

Other advantages of the design include effective isolation of front and rear diaphragm output, effective control of diaphragm behaviour over the audible frequency range, bass response extended smoothly to the bass-driver's fundamental resonance (typically 25 Hz), and effective damping at that frequency.

As far as we can gather the first transmission line speaker was developed in 1936 by Benjamin Olney and demonstrated at the Acoustical Society of America's meeting in Chicago that year. Olney's enclosure was produced by Stromburg-Carlson for some years but was eventually eclipsed by less costly designs.

The transmission line principle appears then to have been largely neglected — particularly in the USA.

Arthur Radford worked on the principle from 1950 onwards — finally marketing his Radford Studio loudspeaker in 1964.

A.R. Bailey of Britain's Bradford Institute of Technology drew world-wide attention to the transmission line speaker in an article published in a 1965 issue of Wireless World. Bailey packed his labyrinth with long-fibre wool and this damped tube-resonance more effectively than Olney's lined walls of thirty years before.

Bailey compared his stuffed labyrinth to the ideal electrical transmission which is free of signal reflections — and test results indicated smooth, extended low frequency response and excellent transient performance.

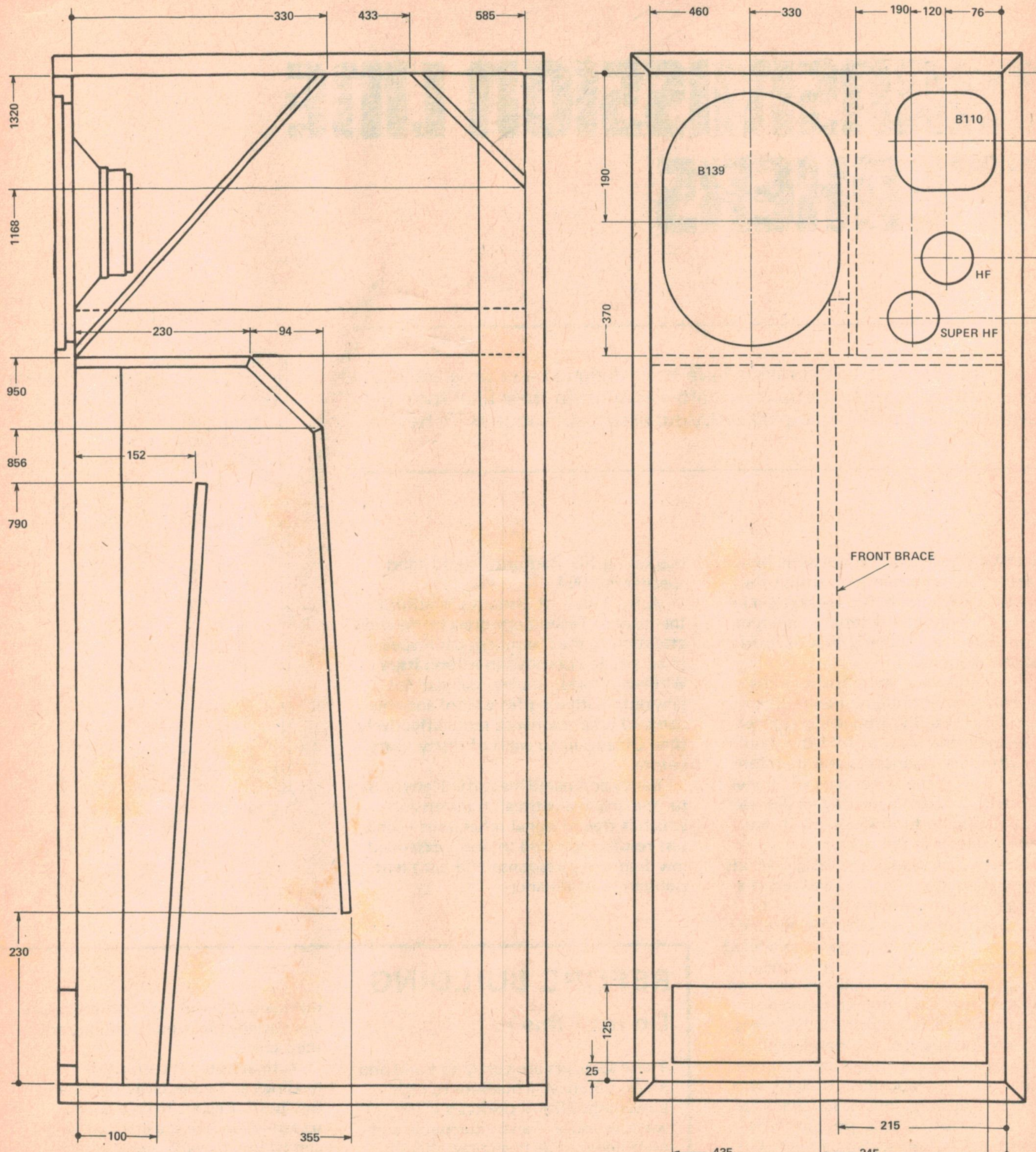
BEFORE BUILDING

Do read this . . .

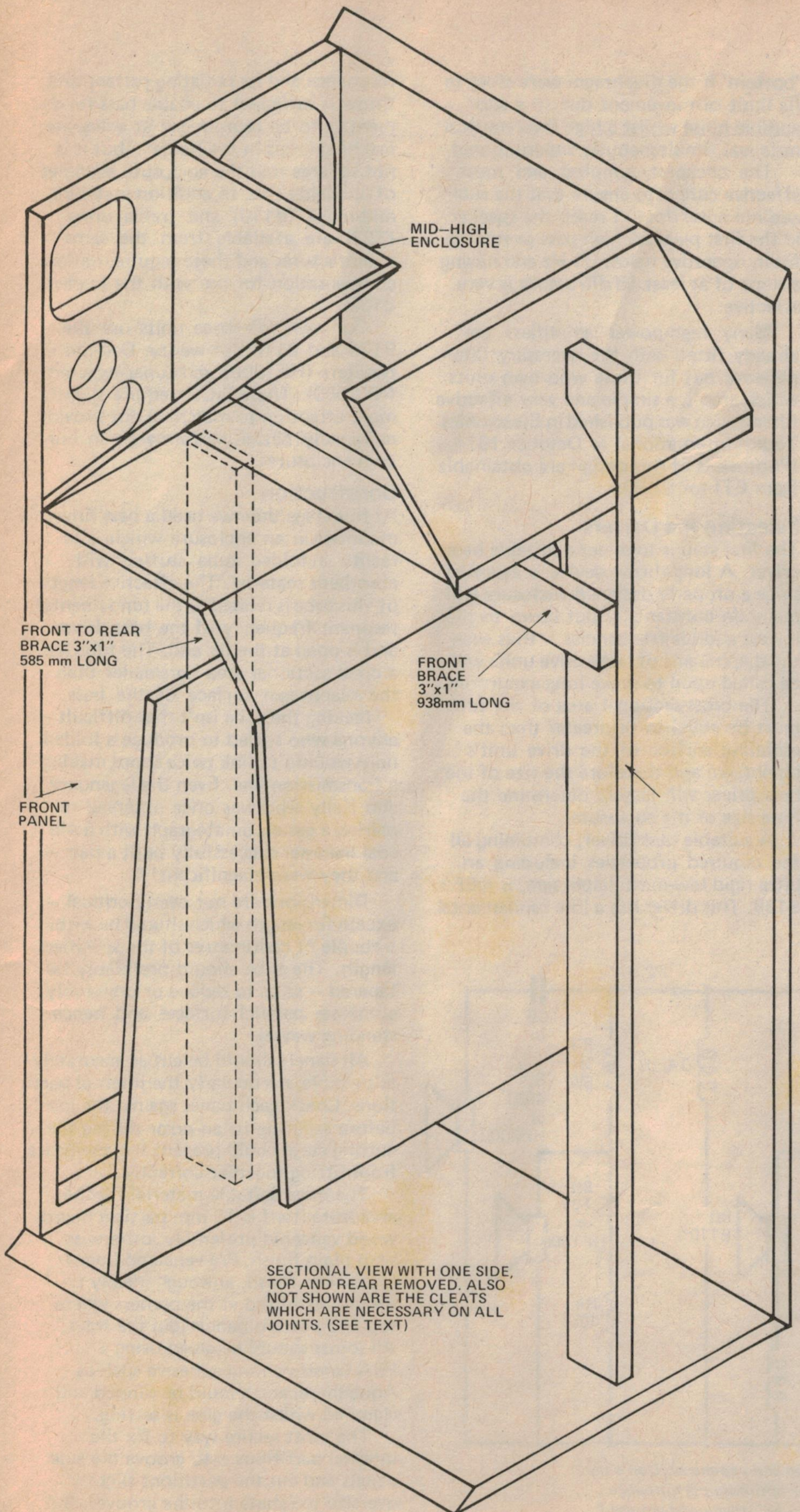
These speakers are costly to build and unless you have a medium to high power amplifier — preferably 75 watts or more — and a turntable and cartridge to match, the benefits of these speakers will not be obtained. They are larger than most and heavy to move around.

But if you accept all this you'll end up with a pair of speakers massively superior to most commercial designs that you could buy for their cost.

A final note: Transmission line loading can't necessarily be called the 'best'. Results from a good transmission line speaker can be almost unbelievably good — but so can the results from the very best reflex units, infinite baffles and horns. The point to bear in mind is not the loading principle itself — rather how it is applied.



Study these drawings in conjunction with the one on the following page. Note that ideally the speakers should be built as a 'mirror-image' pair — that is, so that when placed in the listening room the tweeters should be innermost.



Since those early days the transmission line speaker has to some extent become the only enclosure design seriously considered by many hi-fi people seeking the 'ultimate sound'.

The Operating Principle

The basic principle is simple. It is to load the rear of a bass driver by a tube of 'infinite' length.

For all realistic audio frequencies an adequate compromise is a tube which is one quarter wave-length long at the bass driver's fundamental resonant frequency.

For the drive unit recommended (KEF B139) this tube will be a little over 2.5 metres long and folding it over enables us to produce an enclosure of acceptable size without serious performance compromises.

It's not *quite* that simple for the pipe will produce resonances at its folds and will also have a high-Q resonance at a frequency associated with its length — for the quarter-wave example discussed this will be at about 100 Hz. Some way must be found to 'lose' both the energy causing the resonance and the resonance itself.

There are several ways by which such resonances may be minimized. One is to use many drive units, each having a different fundamental resonance. By careful design it is then possible to cancel out the worst effects of the 'staggered resonances' to give a remarkably smooth response. A form of this principle is used in IMF's ALS-40 which certainly isn't the simple infinite baffle device it appears to be at first sight!

Another method of reducing resonances is to fill the tube with a damping material — and this also increases the effective length of the tube by slowing down the sound travelling within it.

Various materials may be used for this damping. One of the best is long-haired sheep wool; glass-fibre may also be used, it is less effective than wool but tends to be more constant in its physical characteristics.

Resonances caused by the folds in the tube can be minimised by increasing the density of packing material at these points but a far more effective cure is to use a suitable mid-range driver which takes over well below at which the lowest resonance frequency occurs.

Sub-audible Noise

If the tube is correctly packed almost all of the sound radiated from the rear of the bass driver's diaphragm will be ab-

sorbed. Only those frequencies below the driver's bass resonance will reach the far open end of the tube. But those frequencies which are not absorbed cause problems, because at frequencies below resonance the diaphragm 'sees' a very much smaller load and even low level signals at such very low frequencies will produce large diaphragm excursions.

This sub-audible problem is the major drawback with transmission line speakers: even the quiestest turntables produce some sub-audible noise, and modern amplifiers of the quality and power output required to do justice to the speakers will provide a goodly amount of amplification of that noise. It's also most disconcerting to watch the bass diaphragms of transmission line speakers emulating the swoop of the pick-up arm as it traces a warped record. You may argue that your turntable is quiet, that you have optimized your pick-up arm and cartridge to reduce resonant effects — yet every record carries some sub-audible noise introduced during manufacture of the master by the cutting lathe itself and the cutter head mechanism.

In itself, reproduction of sub-audible noise isn't disastrous — it's too low to be heard. But it does affect reproduction indirectly by effectively restricting diaphragm movement and by creating intermodulation components and attendant harmonic distortion. The first problem is the greater — and you can visualise how the bass unit would 'bottom' if the diaphragm were close to its limit of movement due to a sub-audible noise whilst a high level musical note was simultaneously superimposed.

The cheapest, simplest and most effective cure is to ensure that the sub-audible noise doesn't reach the speaker in the first place. A high-pass or rumble filter, operative below 30 Hz and having a slope of at least 18 dB/octave is very effective.

Many high-power amplifiers are already fitted with the necessary filter network but for those who own units which aren't, a simple and very effective filter design was published in Electronics Today International in October 1974. (Photostats of this design are obtainable from ETI for $1.00.)

Selecting the Drivers

The first step is to select a suitable bass driver. A long-throw device is essential since a properly designed enclosure will maintain constant output down to the lowest audible frequencies — thus even the diaphragms of large drive units will be called upon to make long excursions.

The cross-sectional area of the tube must be equal to or greater than the radiating surface of the drive unit's diaphragm and therefore the size of the bass driver will largely determine the final size of the enclosure.

A suitable bass driver, combining all the required properties including an ultra-rigid low-mass diaphragm, is KEF's B139. This driver has a low fundamental resonance and its radiating surface and throw is sufficient to enable bass fundamentals to be reproduced at adequate listening levels in the home — but it is not so large that the enclosure becomes of unwieldy size. In addition matching mid-range (B110) and treble units (T27) are available from the same manufacturer and these require minima compensation for use with the loaded B139.

Our own reference units use the B139 and B110 but we use Celestion tweeters (HF1300) and super-tweeters (HF2000). These latter require slightly more attention to matching but provide marginally better performance in our own enclosures.

Construction

At this stage then we need a bass driver mounted in an enclosure which is in reality a folded tube stuffed with absorbent material. The effective length of this tube is related to the fundamental resonant frequency of the bass driver and is open at the far end. The tube has a cross-sectional area no smaller than the diaphragm surface of the bass.

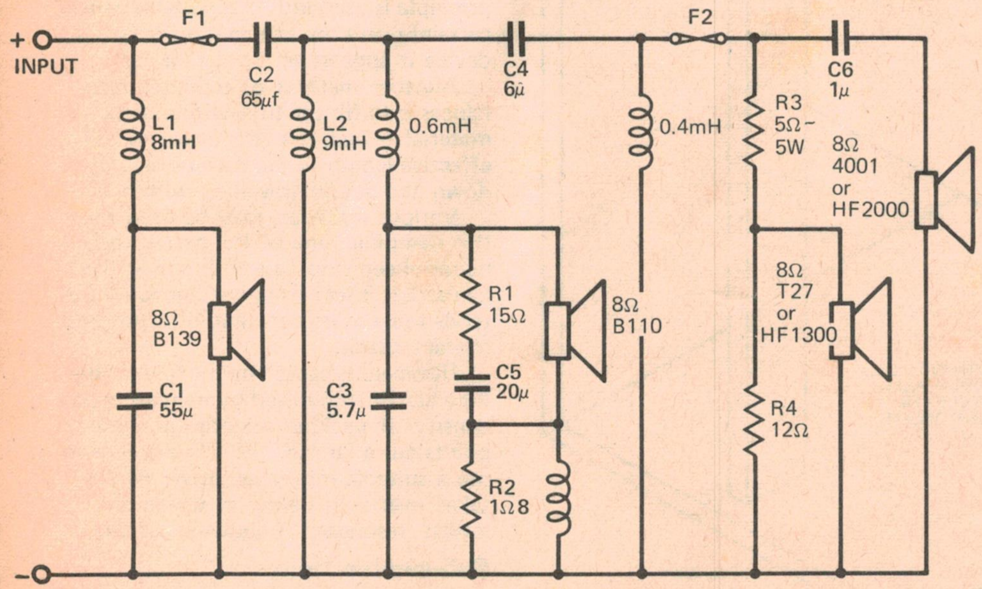
Making the tube isn't that difficult — anyone who's tried to produce a folded horn wouldn't think twice about making a transmission line. Even the legendary Jim Kelly who was once observed repairing a gas chromatograph with a 4lb coal hammer successfully built a pair — and they were magnificent!

Dimensions are not overly critical — except for length which should be within a couple of centimetres of the specified length. The tube should preferably be tapered — so as to reduce or preferably eliminate parallel surfaces and hence standing waves.

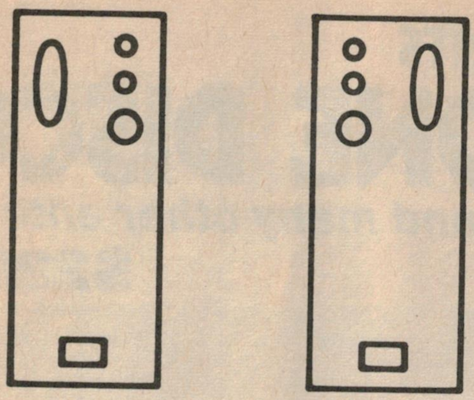
All panels should be cut as accurately as possible, particularly the internal partitions. Check each panel against the job before securing it; an error during the cutting stage could prevent the enclosure from fitting together correctly.

The most suitable material for the enclosure itself is 19 mm particle board, wood veneered preferably, otherwise with plain finish. Pre-veneered board is easier to finish, although ideally it should be mitred at the corners where top and bottom panels join the sides. All joints should be glued using a PBA woodworking adhesive such as Aquadhere, and should be pinned and clamped whilst the glue is setting.

The most secure way to fix the internal partitions is to groove the side panels and cut the partitions slightly oversize to rebate into the grooves. But



Components for the crossover network are both large and expensive. Don't try to economise though, as the design shown is vital for optimum performance. Note that R3 and R4 may be left out if the Celestion HF drive units are used.



Finished enclosures should be located in the listening room such that tweeters are innermost.

this will be beyond the means of most constructors (unless you have access to an understanding cabinet-maker). Cleats, made of offcuts of particle board, or suitable timber, should be provided to give good anchorage. Extra bracing is also an advantage; longitudinal bracing on the 13 mm internal partitions is worthwhile.

Our own units were built by first attaching top and bottom panels to one of the sides. The partitions and midrange sub-enclosure were then added, followed by the rear panel to which connecting terminals and a fuse, mounted on a laminated plastic panel, had already been glued. Wiring was also added at this stage. Next came the front panel — of plywood since this offers greater strength when apertures for drive units have been cut.

All drive units should fit flush; if a Celestion HF 1300 is used, this is designed to be fitted from inside and not from the front. The front panel apertures should therefore be rebated out to accept the drive unit fixing flanges. This involves some rather fiddly chisel work unless you have access to a router.

Once the five sides, partitions and midrange enclosure are in position, the drive units can be mounted and wired to the crossover, which can be placed either on the inside face of the rear panel or on the platform behind the bass unit. The latter position is probably best since it gives access to the network via the bass unit aperture — far easier to remove than the remaining side panel, which should, ultimately, be glued in position once the enclosure is complete.

Drive units originally chosen for our own units were the B139 for bass, KEF B110 for midrange, KEF T27 tweeter and STC 4001K (8 ohm). Later, the T27 and STC were swopped for Celestion HF1300 and HF2000 respectively, (available from the Australian distributor, M&G Hoskins). However, the latest version of the KEF T27 is a vast improvement over the earlier model, and for economy this driver could be used without use of a super-tweeter. The HF1300 exhibits roll-off above 15 kHz and should therefore always be allied to a super-tweeter. Eight ohm versions of both HF1300 and HF2000 should be used, and the drive unit positions indicated on the plan should be adopted, since correct phase relationships are preserved using the crossover network shown.

Our units were filled with fibreglass material — the slab type, not the rolls. This can be secured using suitable pins, or alternatively on small dowels inserted through holes in the partitions and subsequently glued and sealed. It is *essential that all joints* are fully airtight otherwise the enclosures will fail to work correctly. The fibreglass should fill all the available space in the 'line' yet should not be compressed. Density may be increased slightly at bends in the tube. Final adjustment is best done by careful listening and experimenting with packing density. That's why the remaining side panel should be secured by screws. Gaskets should be used to ensure the enclosure is sealed.

Long-fibre sheeps' wool (Dr. Bailey's long hair!) can be used, although this is more difficult to work with and may settle after a period of time, with a consequent change in performance. Bonded acetate fibre such as Innerbond may be used, tightly packed — although not overtightly — in the midrange enclosure. It should not be used in the bass section.

When the enclosures are correctly packed with fibreglass, bass performance should be smooth and extended, with no obvious constriction or colouration. However, *there may be an apparent lack of bass energy by comparison with many speakers,* although fundamentals will be clearly defined and 'tight' sounding.

Transmission line speakers accurately reproduce the bass that is in the original programme material. No more — and very little less. They don't manufacture bass in the form of resonances.

Our crossover network is based on air-cored coils supplied by Transcap (Orchard Road, Brookvale, NSW). All capacitors are paper or polyester, the 55 and 65 microfarad values being made up of oil-filled paper fluorescent lighting ballasts from Plessev Ducon.

Values for R3 and R4 can be altered to achieve correct balance between midrange and treble, and these values actually depend on the drive units chosen. These resistors might best be left out completely if Celestion HF drive units are used.

Fuse protection may be considered necessary if high levels are envisaged — 3 amp fusing should be adequate. The tweeters can be protected separately by a 1 amp fuse. Fuseholders should be fitted in some accessible position such ad adjacent to the input terminals.

Our prototypes were used for a long period of time as a high-quality reference speaker system for evaluating the subjective performance of hi-fi equipment and assessment by comparison or other loudspeakers. They were used in mirror-image form, with the enclosures positioned so that each array of tweeters was innermost. This provides optimum stereo performance, since the main axis of each speaker projects into the room, away from boundary walls. Reduction of reflected sound by this means was found to provide a less anomolous stereo image.

Reticulated foam is recommended for the grilles since this causes less colouration than frame/fabric grilles. The prototypes used open grilles constructed of aluminium channel, and these proved aesthetically pleasing and sonically satisfactory.

Once all internal adjustments have been made, the detachable side panels may be secured and sealed in position. It would be advisable, however, to leave these panels removeable in case access to the interiors is necessary in the future.

Overall, the systems as described performed admirably and despite their size, were found to take up little effective space due to their tall, tower-like format.

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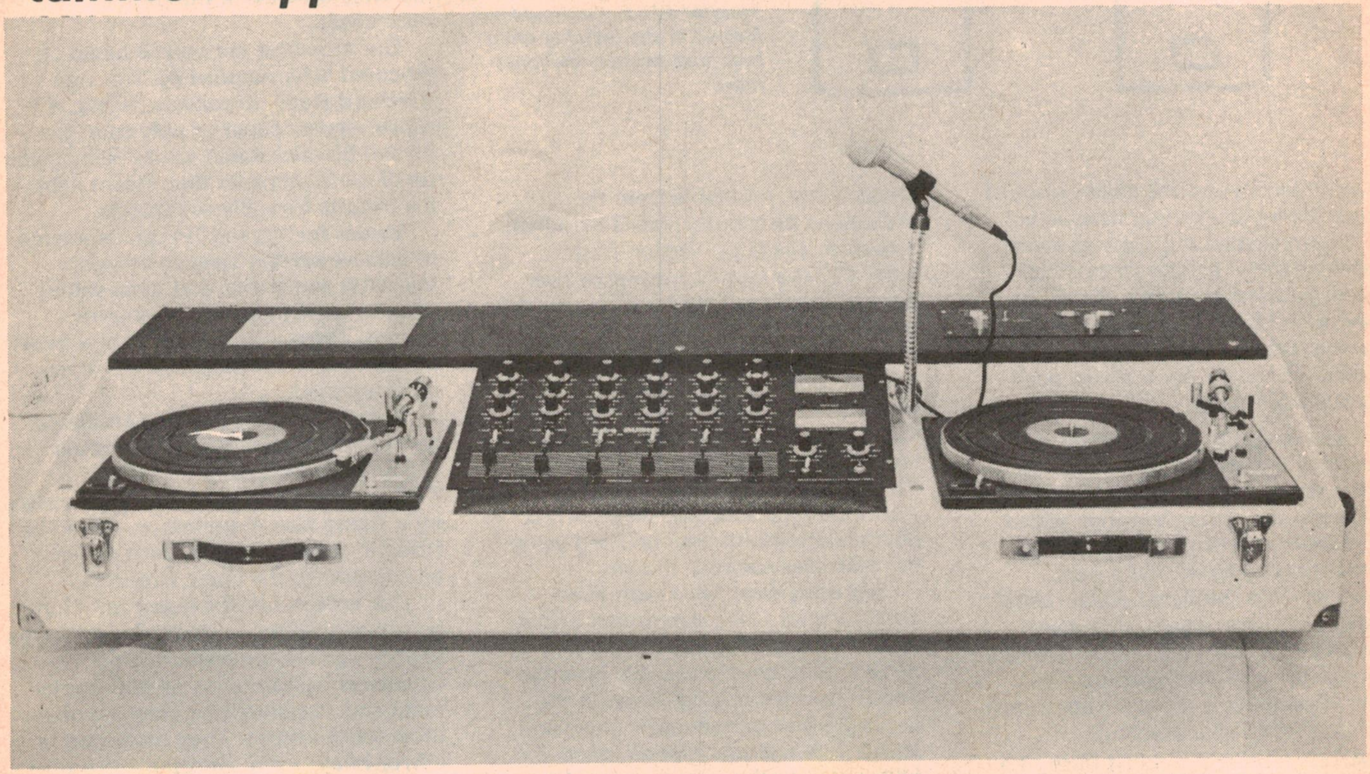

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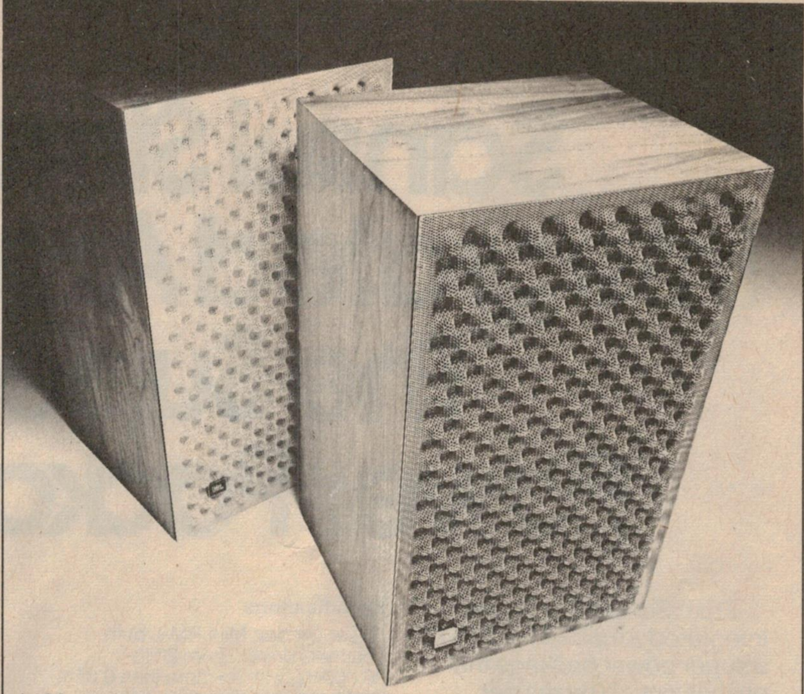
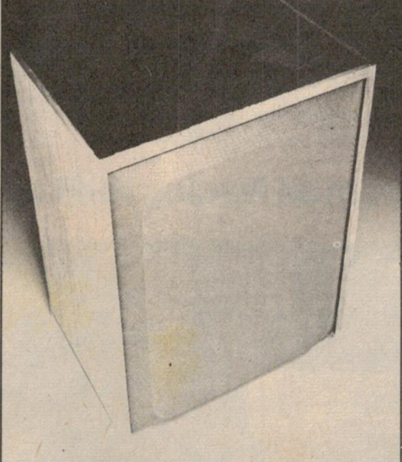


L166—the most accurate bookshelf loudspeaker JBL has ever made. Oiled walnut finish with the most acoustically transparent grille ever created.



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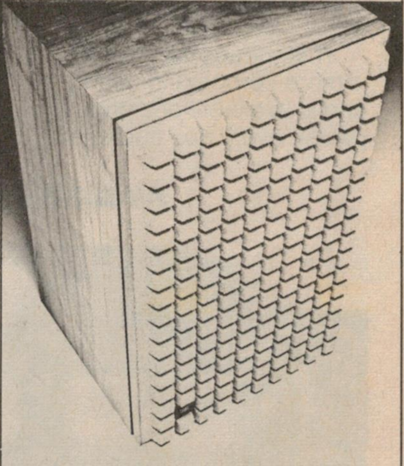

L100—The three-way twin of a JBL professional studio monitor. Oiled walnut finish with blue, orange or brown air foam grille.

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From Sansui, the Stereo Integrated Amplifier AU20000, a super power package that pushes out 170 watts per channel. We call it integrated because it is a combination of the Definition BA-3000 power and CA-3000 preamplifier within the one unit.

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Power Output: Min. RMS, both channels driven, from 20 to 20,000Hz, with no more than 0.05% total harmonic distortion 170 watts per channel into 4 and 8 ohms.
Power Bandwidth: 20 to 20,000Hz at or below rated min. RMS power output and total harmonic distortion.
Total Harmonic Distortion: Overall (from AUX) less than 0.05% at or below rated min. RMS power output.
Intermodulation Distortion: (70Hz:7,000Hz = 4:1 SMPTE method). Overall (from AUX) less than 0.05%.
Frequency Response (at 1 watt): Overall (AUX to power output) 10 to 50,000Hz + 0dB, −1.0dB
Power Amplifier Only 10 to 70,000Hz + 0dB, −1.0dB
Damping Factor: approximately 80 to 8 ohm load
Channel Separation at rated output 1,000Hz:
Phono 1–better than 55dB (at 3mV sensitivity)
Phono 2–better than 55dB (at 3mV sensitivity)
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SOUND

Elcaset Latest

This magazine has for many years maintained that the general acceptance of the standard tape cassette as a true hi-fi medium is unfortunate — if you wrap enough technology around it the results are a great deal better than one would expect. But the basic principle is still wrong.

Hence our enthusiasm for the Elcaset format. Few engineers would dispute the inherent superiority of the Elcaset format — it's wider tape width and faster tape speed just *have* to be right. In fact the Sony Elcaset unit which we reviewed in December 1976 (incidentally this was a world-first) showed that performance was right up with the best of reel-to-reel machines.

But no matter how good the Elcaset system is technically it will ultimately stand or fall on market acceptance. Hence our recent pleasure at learning that Technics have an Elcaset tape deck.

The Technics RS-7500US is a front panel loading machine—all the controls are also on this panel. Tape width is of course 6.3 mm (¼") and tape speed is 95 mm/sec (3¾"). The maximum output (MOL) at 10 kHz is almost 15 dB higher in the RS-7500US than levels attainable in cassette decks while a frequency response of up to 20 kHz (on par with open-reel tapes) is possible with chrome and ferri-chrome tapes. Once the Elcaset is inserted into the tape compartment, the tape is pulled out from its case, and pressed against the heads. Mechanical parts like the capstan, tape guides, and heads remain quite stationary, just like open-reel decks. In the RS-7500US, the tape is "threaded" immediately when the Elcaset is inserted, putting it into standby mode, ready for instant recording or playback.

Another of the unique features of Elcaset is the automatic sensing and switching of the different types of tape available

(Type I — low-noise high-output, Type II — ferri-chrome, and Type III — chrome). Special identification recesses along the back edge of the Elcaset case are detected by built-in sensor devices in the RS-7500US, which then automatically switches to the appropriate bias and equalization circuits. Front panel indicator lamps show which type of tape is being used.

The tape compartment has a built-in illumination lamp to show how much tape is on both reels, and an oil-damped eject mechanism for smooth unloading. Full auto-stop mechanism is activated by a LED/photosensitive transistor arrangement which detects the transparent leader when it passes the auto-stop window, thus avoiding any kind of unnecessary tape strain.

Cassettes That Work

The most important single requirement of a cassette tape is that it works. No matter how good its frequency response or freedom from 'dropouts' all is pointless unless the tape can be transported from the beginning through to the end and back again — and keeps on doing so.

This would seem a totally obvious requirement but we for one (for *how* many? — Ed) have have a small bin full of mechanically faulty cassettes with impeccable magnetic characteristics.

Fortunately most of the major cassette manufacturers take mechanical reliability very seriously — particularly the French company Pyral.

Pyral are relative newcomers to the Australian audio scene — and the reaction of most audio amateurs is to say 'Py-who?'. But Pyral are one very big company indeed — the industrial group to which they belong (Rhone-Poulenc) is the ninth largest in the world to maintain which it has the third largest company budget for research and development worldwide. And they make every conceivable type of recording tape product from studio mastering bits and pieces to instrumentation tape used amongst other applications in the Concorde aircraft.

The Pyral company recently established a manufacturing subsidiary company in the UK (Pyral Magnetics Ltd., Courtland Rd., Eastbourne, Sussex) and it is this company's audio cassette products which are being introduced in Australia.

Apart from the standard ferrite type of cassette, Pyral also produce a 'cobalt-active' formation which provides truly excellent overall performance without the need for bias switching that is essential with chrome types.

The gentlemen selling Pyral tapes in Australia are naturally anxious that as many people as possible should know just how good they are. And you can believe us that they *are* good. So they're offering them to you (and to readers of our associated publication Hi-Fi Review) for an extraordinarily low introductory price. You'll have to buy a minimum of ten, but at 99 cents each *including postage* for standard low noise C90s, they're a steal!

The offer is spelt out on page 36 of this issue. We've tried and tested a number of these tapes and they are *GOOD.*

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Quantum surpasses other leading premium open reel tapes in overall recording performance. Specific performance advantages offered by Quantum include:

Greater Sensitivity.
Quantum offers several dBs more output than other premium open reel tapes for the same record drive.

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Quantum offers lower third harmonic distortion (THD) than other premium open reel tapes.

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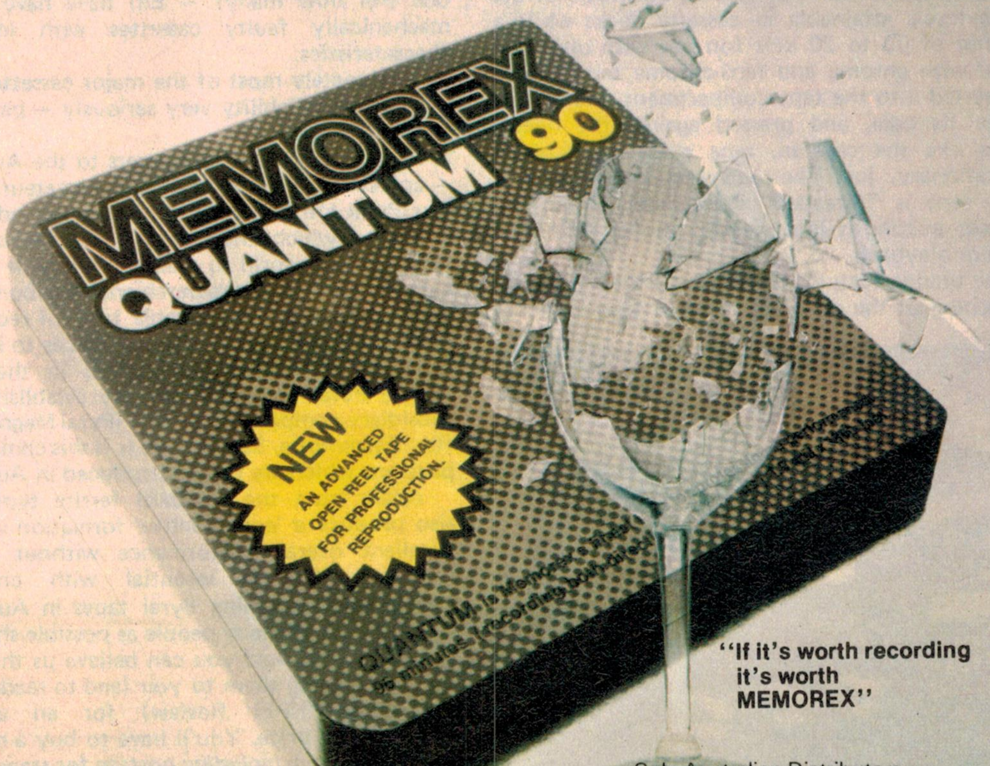
Quantum offers up to several dBs more output at 3% THD, and because Quantum has more output and greater sensitivity with no increase in noise, the signal/noise ratio is greater than other premium open reel tapes.

Higher 10 KHz Saturated Output.
Quantum offers up to several dBs more saturated 10 KHz output than other premium open reel tapes, thereby providing greater dynamic range.

All these performance characteristics add up to the best premium open reel tape widely available. Testing supports this promise. Memorex Quantum has been tested against other leading premium open reel tapes, and has outperformed them all.



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CHARTWELL LS3/5A MONITOR SPEAKERS

LS3/5A is the serial number of a BBC monitor loudspeaker specification. The BBC, of course, has a research department which continually studies general broadcasting standards, and as part of these activities evolves practical loudspeaker designs. The specifications cover performance and physical parameters: usually manufacturing is entrusted to outside contractors, who may or may not be licensed to sell loudspeakers to BBC spec. on the opern market. Well-known commercially available examples of BBC monitors are the Rogers BBC monitors and Spendor BC1. As a point of interest, the renowned Celestion HF1300 tweeter was produced in response to BBC needs, and this drive unit has featured in many designs used by the Corporation. This explains why the HF1300 rolls off above 15 kHz — the upper limit of audio frequency response for FM broadcasting.

Chartwell's LS3/5A is an example of a commercially-made BBC monitor. But what an unexpected loudspeaker it is! One immediately thinks of broadcast monitor loudspeakers as huge, elaborate, no-compromise systems. But the Chartwell is a tiny device, smaller than a shoe box and, if memory serves us correctly, marginally smaller than the original hi-fi miniature, the Maxim by Goodmans.

Specification LS3/5A actually calls for a speaker small enough to be used in mobile control rooms (Outside Broadcast vans). It takes little stretching of the imagination to think of LS3/5As sitting on the rear parcel shelf of the family car, giving the ultimate quality in car stereo. But for car use, there could be problems. The main compromise in a small speaker of this sort — assuming bass response to be reasonably well maintained — is efficiency, and it would take something like the new high-power in-car amplifiers to operate Chartwells successfully.

The LS3/5A is a two-way, two drive unit system using an infinite baffle enclosure. Chartwell, which itself manufactures a number of drive units, has actually used KEF components in this design. A modified B110 covers bass and midrange, whilst a more heavily modified T27 handles HF. The T27, to judge by samples we received for review, is virtually unrecognisable as such. It is fitted with a perforated convex front cover, which fits over the diaphragm in a similar way to the cover on Celestion's HF2000. We imagine this is designed to improve phase linearity off axis, and no doubt a useful amount of loading is provided across the lower part of the range handled by this unit.

The front panels of our samples were made from plywood, stronger than particle board and less likely to cause colouration through resonance. Curiously, the B110 has been mounted behind the panels, and we assume this must be for the purpose of improving behaviour behind the diaphragm. When mounted flush to a 19 mm panel, the open chassis of the B110 is partially covered — and the aperture could probably be responsible for significant colouration, particularly at low frequencies where air flow from the diaphragm rear surface would be severely restricted.

The T27 is mounted, predictably, flush with the front panel and is surrounded by bolsters made of felt. The grille, which makes an audible contribution to the result, is secured with velcro fastening to the front panel. Grille material of our samples was woven synthetic fabric stretched over a frame.

Diminutive

Beside our monster reference speakers, the Chartwells looked ridiculously diminutive. Perched on their stands, they looked no match whatsoever for several different types of speaker in the listening room at the time. It was a revelation not only to hear the LS3/5As sounding excellent, but to hear them sound considerably better over the upper frequency region, compared with some of the other speakers. Even our reference speakers, which have been auditioned keenly since their first appearance by many pairs of critical ears, came under scrutiny after onslaught by the Chartwells.

One major and several minor design modifications were made to the references after this first comparison with the LS3/5As. Extreme bass output from the Chartwells was, of course, almost non-existent. Roll-off seemed to occur below about 90 Hz and at a steep slope, too. But roll-off was smooth and unobtrusive. It was distracting at first to switch to the Chartwells from references and lose the weight from the bottom end, but it was also obvious that a careful compromise had been made regarding what would be needed to give musically satisfying performance, for after a brief acclimatisation period, the Chartwells sounded delightfully natural.

Upper bass was defined with a rare lack of resonance, giving a delightfully open-textured quality. Midrange was totally free of stridency, and had a firm, projected quality without an exaggerated presence. Treble complemented this superbly, with a restrained clarity which sounded neither too much nor too little. However, it was possible to hear the spikiness characteristic of the T27 drive units — much suppressed in these Chartwells but nevertheless just audible somewhere at the top of the midrange region. Certainly none of the hardness

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characteristic of early T27s was noted — KEF solved most of that particular problem with the introduction of the revised SP1032 version. The effect of this spikiness in the LS3/5A was to introduce the slightest trace of harshness with certain types of sound — notably orchestral strings and human voices both singing and speaking. We were forced to listen very hard, however, to establish that this fault really existed!

Predictably, stereo performance was superb, with first-class perspective and well-defined width. We were less happy with transient performance, not so much because this was poor or anything like it. But we simply were unable to drive the speakers really loud, since our amplifiers (Sugden C51s) clipped and the B110s were beginning to 'pole' and introduce large quantities of intermodulation components. But using low initial levels, more appropriate anyway in small rooms, transients were nicely defined without serious loss of dynamic impact.

Stands

Midrange colouration was noted when the speakers were used on shelves or similar flat surfaces; stands will seem to be essential for best performance.

We predict these speakers would appeal to the person who by force of circumstances can't entertain the idea of large speakers and is seeking top performance nonetheless. Good ancillaries are essential for the LS3/5As and we would hesitate to recommend much less than a fifty or sixty watt per channel amplifier to drive them. Nor do we feel an amplifier as powerful as 150 or 200 watts per channel excessive, although some kind of overload protection would be appropriate in such circumstances.

There are many larger speakers costing less. Very few of them can approach the performance quality of the Chartwells, which also happen to sound rather better than a majority of speakers costing to or three times more.

SOUND BRIEFS

SUPER-WOOFER FOR CHARTWELL

McGlew and Company, South Australia, distributors of Chartwell loudspeakers, advise that a **super-woofer** is shortly to be introduced for use with the LS3/5A speakers reviewed in this issue. The super-woofer will use a **KEF bass driver in a transmission-line** enclosure and is designed for use with electronic crossover arrangements.

CROSSTALK BECOMES CROSSWHISPER

A clever new circuit by Denon, incorporated in the new PMA-501 and PMA-701 integrated amplifiers, is a **crosstalk reduction device** for pickup cartridges. First indications are favourable; it really works!

ONLIFE VISITOR

A recent welcome visitor to Australia was Dr. Tominari of Onlife Research, the engineer responsible for Dynavector moving-coil cartridges. Chief topic in an address in Sydney was the new **Onlife high-mass arm** — of which more details soon.

VALVES

Seen at Dr. Tominari's reception was a new range of **valve-based amplifier** components. Expect to see them on sale in late spring.

ROOM FOR JH

As we pointed out in last month's report on the Linn Sondek LP12, the transparent plastic cover doesn't give **enough headroom** for a Formula 4 arm. Riverina Hi-Fi's solution is a bubble in the cover a la Technics SL-120 etc.

STEREO SPEAKER SYSTEM FROM JBL

A newcomer to JBL's range is model L-121, consisting of a pair of midrange/hf panels operating above 70 Hz and a common bass bin, with built-in amplification and equalisation, operating from **28 Hz to 70 Hz**. In best JBL tradition, the bass bin is fitted with a glass top for use as a coffee table.

QUADRAPHONIC SUGDEN

J.E. Sugden (U.K.) has introduced a **4-channel matrix decoder**. Styled to match the C51 control unit and R51 tuner, the new unit will soon be available in Australia.

The fabulous accuracy of Quartz PLL without having to hock the family jewels.

PL-550

When you've been in the business as long as we have, you know how to create a turntable that sets the standard for rotational accuracy without setting a record for exorbitant price. In our PL-550 direct-drive turntable, we used the most precise speed control system there is. With Pioneer's Quartz PLL (phase-locked loop) method, the output waveform of a generator on the rotor of the motor is compared with the waveform of the Quartz element reference oscillator. A solid-state phase comparator insures that the precision of rotation is perfectly identical to the precision of the Quartz oscillator.

In addition, advanced fabrication techniques have resulted in reducing the wow & flutter to no more than 0.025% (WRMS) and increasing the S/N ratio to more than 70dB (DIN B). After that, the high-torque motor resists even the most minute amounts of friction from stylus pressure for outstanding rotational precision.

The visual manifestation of this incredible accuracy is displayed on the built-in strobe. In comparison to conventional types, the PL-550's strobe utilizes only one row of markings. In addition, a conventional light source powered by line voltage is subject to fluctuation of up to 0.1%. In the PL-550, strobe lighting is Quartz reference pulsive lighting unaffected by changes in power supply frequency.

Tonal quality is further enhanced by the high-trackability of the S-shaped tone arm. High precision angular contact bearings prevent deterioration in the mid and high frequency range and a thick aluminum mounting base assures integrity in the bass range. An anti-skating device eliminates harmful inward forces and a cueing device protects records and stylus against accidental damage.

And for protection from outside influences, the monocoque design cabinet combines the ideal weight/mass ratio with large solid insulators.

Pioneer's PL-550 Quartz PLL direct-drive turntable. When it came to building in high performance accuracy, we held nothing back. When it came to keeping the price down, we made everything count.

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642 Albany Highway,
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2650 Games Software Package – Newly released Astro-Trek (Yes the SPACE Trek game) now available (requires only 3 k of memory) Other games include Hangman, Nim, Mastermind, Target Shooting, Number Guessing and more. Package includes computer verified cassette tape (110 Baud Pipbug format) program listings and instructions. $12.50

MARINE GAS ALARM

This versatile alarm prevents the motor being started or electrical equipment used if there is a build up of petrol vapour or LP gas thus protecting your boat against fire.

PETROL VAPOUR, closed space and electrical sparks are not ideal companions. Many a boat has been destroyed when the owner has switched on the ignition without realising there had been a petrol leak and that the vapour content in the engine compartment is at a dangerous level. Unfortunately the circumstances also lead to injury and loss of life. Therefore any system which can prevent this is of great value.

This unit is designed to meet this requirement and uses a semiconductor gas detector (TGS cell) to monitor the atmosphere in the engine compartment and either prevent the engine being started or shut it down if a high vapour concentration occurs during operation.

Construction

This is relatively easy if the printed circuit board is used and the wiring diagrams are followed. Some precautions should be taken if the unit is to be used in a boat to prevent corrosion. The rear side of the board should be coated with a cellulose spray (dope, nail polish, etc.) and the box, while having to be near the control panel, should be shielded from direct spray. Although we have used a separate box the unit can be mounted behind the control panel if desired.

A small heatsink (about 25 mm square aluminium) should be bolted on to IC1 to keep it cool.

The relay we have specified can handle up to 6 A current but if higher currents are required it can be replaced with any 12 V relay providing its coil resistance is over 100 ohms.

Obviously the sensor must be mounted in the engine compartment and while it must be in free air it must also be protected against mechanical damage.

Installation and Adjustment

The sensor should be mounted in a position where vapour may be expected and should be mechanically protected against damage. The connection to the sensor should be via a 4 core cable (on long runs use a shielded cable) and the connection of the sensor is shown in Fig. 2. Note that it is symmetrical in layout and also the fact that it will fit into a standard 7 pin miniature valve socket.

The only adjustment is the sensitivity control and this is set by bringing a small container of petrol near the sensor and ensuring it operates. The adjustment should be as sensitive as possible without giving false operation.

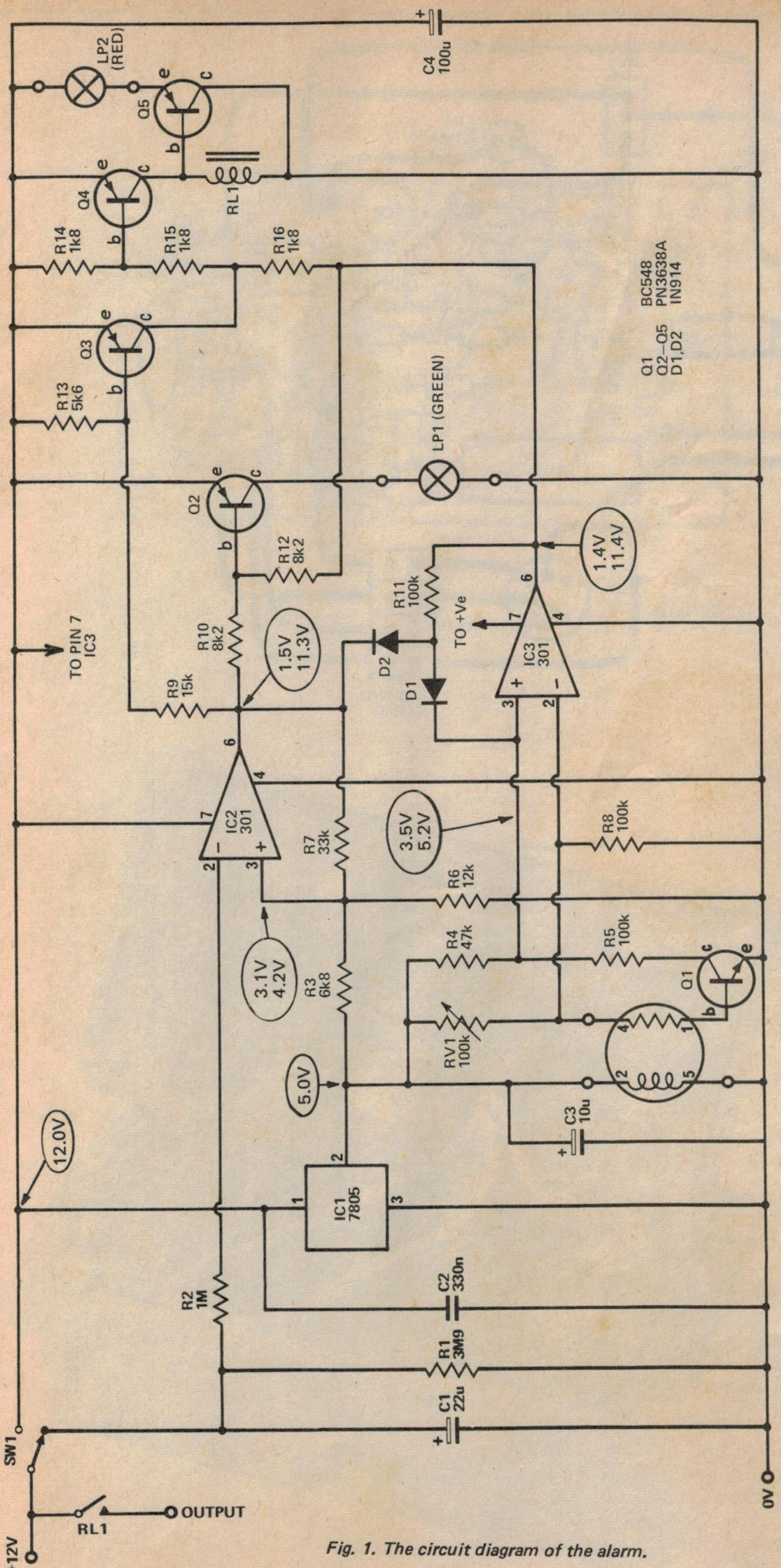


Fig. 1. The circuit diagram of the alarm.

HOW IT WORKS – ETI 583

This project is designed primarily to monitor the concentration of volatile gases inside the bilge of petrol-engined boats. The circuit provides an electrical cutout which prevents the engine from being started if fumes are present and also will remove all electrial power if fumes become present at any time.

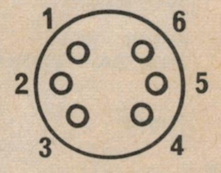
The unit acts as a master switch and due to its warm up requirements, a two minute delay occurs on switch on. Two indicator lights indicate either "safe" or "fail" condition and in the initial warm up period both lights are on. The initial timing is performed by C1 and IC2. With the main switch off there is +12 V across C1. When it is switched on the capacitor is allowed to discharge through R1. IC2 compares the voltage on C1 with that on pin 3 (about 3 V). During this period the output of IC2 will be about +2 V.

IC1 is a 5 V regulator and supplies the power for the heater of the sensor. The sensor's resistance element is in series with RV1 and this voltage is compared to the voltage set by R4/R5.

The transistor Q1 gives a fail safe operation and if the sensor is not connected this transistor will be off giving +5 V on pin 2 of IC3. Resistor R8 ensures that the voltage on pin 2 will always be slightly less than +5 V.

If vapour is present the sensor resistance will be low and the output of IC3 will be high. During the first two minutes the diodes D1 and D2 prevent the feedback loop (R11) operating. After two minutes if the output goes high the reference voltage on pin 3 of IC3 will go above 5 V and therefore the IC will latch in that position.

The relay is operated by Q4 and for it to close the output of IC3 must be low (no vapour) and also the output of IC2 must be high (more than two minutes after switch on). If the unit does switch off, or prevents initial switch on, it must be switched off and then on again (after clearing the fumes) and the two minute delay operates again.



Underneath view.
Note that pins 1 and 3 are internally connected as are pins 4 and 6.
Polarity is not important.

Fig. 2. Connections of the sensor.

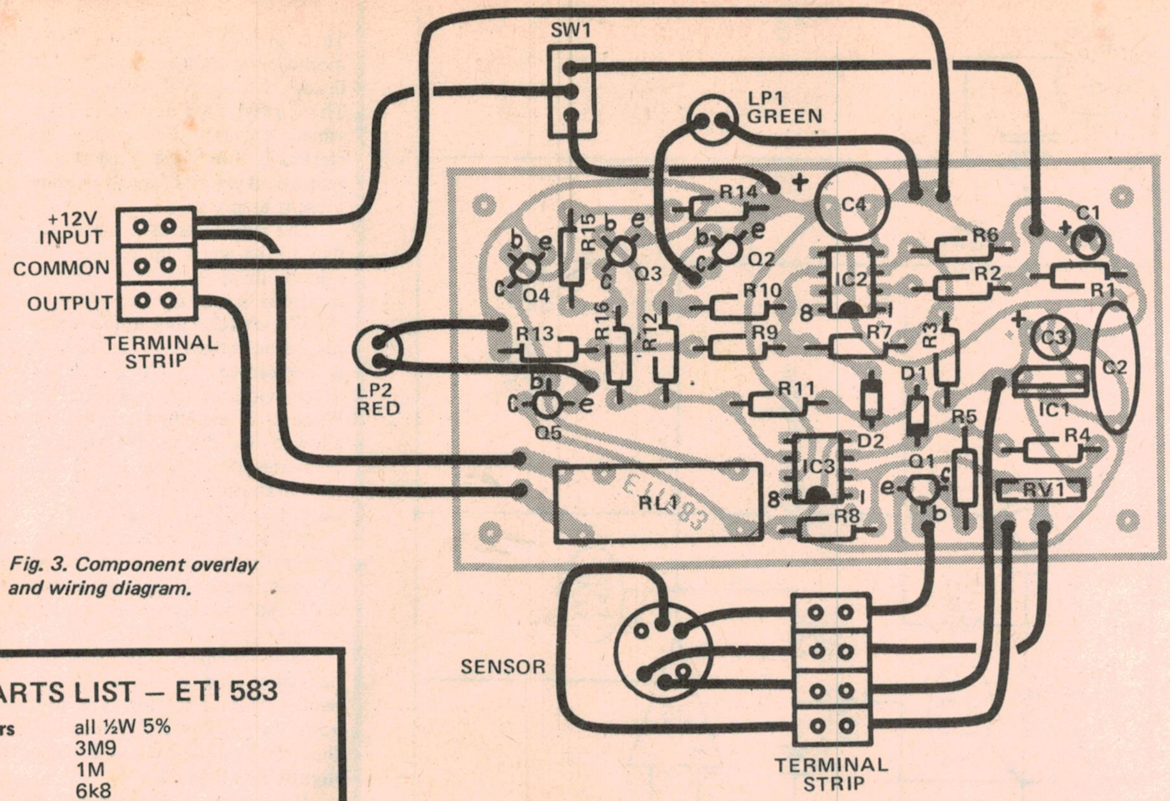
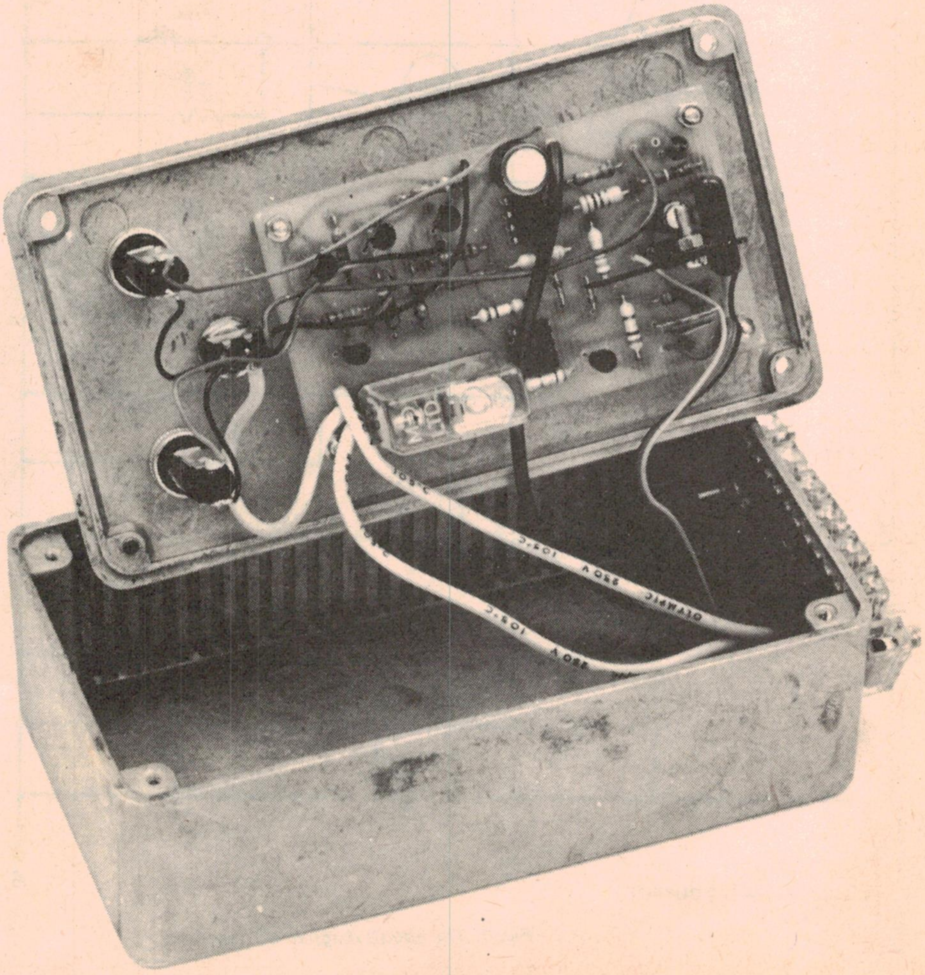


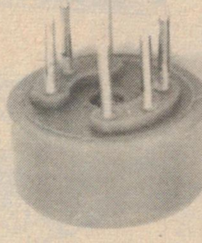
Fig. 3. Component overlay and wiring diagram.

PARTS LIST – ETI 583

Resistors	all ½W 5%
R1	3M9
R2	1M
R3	6k8
R4	47k
R5	100k
R6	12k
R7	33k
R8	100k
R9	15k
R10	8k2
R11	100k
R12	8k2
R13	5k6
R14-R16	1k8
Potentiometers	
RV1	100k trim
Capacitors	
C1	22µ 16V tantalum
C2	330n polyester
C3	10µ 16V electro
C4	100µ 25V electro
Semiconductors	
IC1	7805 regulator
IC2,3	301A op amp
Q1	BC548
Q2-Q5	2N3638A, PN3638A
D1,D2	1N914
Miscellaneous	
TDG sensor	812 or 813
PC Board	ETI 583
LP1,2	Indicator lamps 12V 100 mA max.
SW1	single pole toggle
RL1	12V relay 280Ω coil single pole (E3201)
Metal box to suit	

The TDG sensors are available from Digitron Engineering, P.O. Box 177, Bexley, NSW 2207 for $9.78 including sales tax.





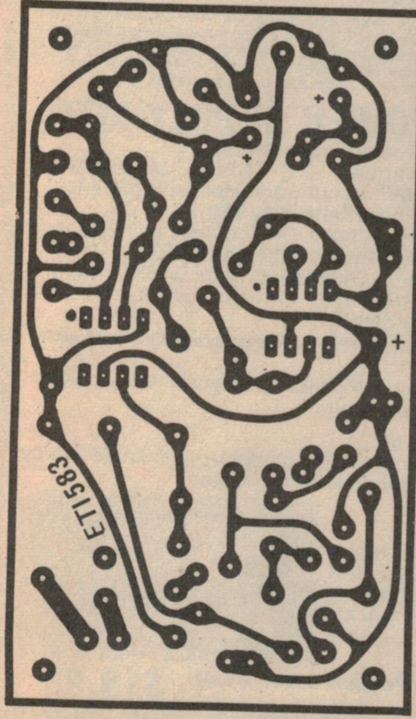


Fig. 4. Printed circuit layout. Full size 52 x 92 mm.

E E E

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CA3053	1.70	CD4085	1.65	LM555H	1.95	SL917B	6.50	7407	1.09
CA3059	8.40	CD4086	1.65	LM556N	2.95	SL1310	1.60	7408	1.09
CA3060	8.40	CD4093	1.80	LM562B	10.90	SL3046	1.20	7409	.48
CA3079	4.40	CD4502	2.70	LM565N	3.50	SP8505	8.60	7410	.48
CA3080	2.10	CD4503	1.40	LM566CN	2.50	SP8515	12.90	7411	.54
CA3081	2.70	CD4510	3.20	LM567CN	3.50	TAA300	2.90	7413	1.15
CA3082	2.70	CD4511	3.30	LM709N	.95	TBA750	2.90	7414	2.70
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CA3090Q	6.90	CD4518	2.85	LM723N	1.25	TCA220	2.25	7422	1.95
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CA3120E	4.50	CD4520	2.55	LM733CH	2.70	TCA420A	4.90	7426	.70
CA3127E	4.50	CD4528	1.80	LM733N	2.50	TCA580	6.50	7427	.66
CA3128E	9.90	CD4539	1.98	LM741CH	1.20	TCA730	6.90	7430	.48
CA3130T	2.25	CD4555	1.80	LM741CN	.75	TCA740	6.80	7432	.66
CA3140T	2.25	CD4556	1.80	LM747CH	2.70	TDA1005	5.50	7437	.90
CA3600	3.30	CD4720	12.60	LM747CN	2.50	UAA170	3.25	7438	.90
CD4000	.55	CD4724	3.85	LM748CN	1.20	UAA180	3.25	7440	.48
CD4001	.55	CD40097	1.80	LM1303N	2.60	UA723C	LM723	7441	2.80
CD4002	.55	CD40098	1.80	LM1310N	3.50	UA757	3.80	7442	2.60
CD4006	2.30	CD40174	2.90	LM1458N	2.50	ULN2208	2.45	7445	2.60
CD4007	.55	CD40175	2.90	LM1488N	6.90	ULN2209	2.45	7446	2.60
CD4008	2.35	CD40192	2.90	LM1489N	5.75	ULN2111	2.10	7447	2.60
CD4009	1.50	CD40194	2.90	LM1496N	1.90	74C00	.55	7448	2.60
CD4010	1.50	CD40195	2.90	LM1808N	3.90	74C02	.80	7450	.48
CD4011	.55	DM8097	1.90	LM3028	CA3028	74C04	.55	7451	.48
CD4012	.55	HEF see "CD"		LM3046	3.60	74C10	.65	7453	.48
CD4013	.90	LH0070	6.20	LM3086	3.75	74C14	2.80	7454	.48
CD4014	2.40	LM114H	4.90	LM3900	1.75	74C20	.75	7460	.48
CD4015	2.40	LM301AN	.95	LM3905	3.90	74C85	3.90	7470	.85
CD4016	.90	LM301CN	.95	LM3909	1.50	74C86	2.00	7472	.75
CD4017	2.25	LM304H	3.80	MC1035P	2.90	74C90	2.50	7473	.80
CD4018	2.25	LM305AH	3.80	MC1312P		74C154	5.70	7474	.95
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CD4023	.55	LM311A	3.60	MC1454G	5.40	74C901	1.95	7483	2.30
CD4024	1.75	LM311H	3.60	MC1458	LM1458	74C925	16.70	7485	2.95
CD4025	.55	LM312H	4.90	MC1468L	6.50	80C95	2.20	7486	.85
CD4026	3.30	LM317K	6.90	MC1488	LM1488	MISC		7489	4.50
CD4027	1.05	LM318N	5.90	MC1496K	2.75	AL5352	1.50	7490	.90
CD4028	1.80	LM319H	7.25	MC1590G	6.75	GL4484	1.80	7491	1.90
CD4029	2.65	LM319N	5.90	MC14553	12.50	GL5253	.90	7492	1.20
CD4030	.95	LM320K	6.90	MC1648P	4.90	OL31	.90	7493	1.20
CD4031	4.70	LM320T	4.50	MC4044P	4.90	RL4484	.39	7494	2.20
CD4035	2.35	LM322N	4.50	OM802	3.20	RL5023	.35	7495	1.65
CD4040	2.50	LM323K	7.90	SAJ110	2.50	FND357	3.50	7496	2.15
CD4041	2.50	LM324N	4.50	SAK140	2.50	FND500	3.50	74100	3.65
CD4042	1.95	LM325N	4.50	SD305DE	1.30	9001	1.80	74107	.95
CD4043	2.25	LM326H	4.50	SD306DE	1.50	9368	3.85	74121	1.20
CD4044	2.25	LM339N	3.70	SL415A	2.70	9601	2.90	74122	1.20
CD4045	3.20	LM340K	4.95	SL425A	1.80	NSN71	2.90	74123	1.40
CD4046	3.20	LM340T	2.70	SL437D	3.60	NSN74	2.90	74132	1.90
CD4047	1.95	LM349N	4.50	SL440		TIL306A	13.80	74141	2.75
CD4049	.90	LM358N	3.20	SL442	2.90	11C90		74145	2.95
CD4050	.90	LM370H	4.95	SL447	4.90	95H90	14.50	74150	3.25
CD4051	2.25	LM371N	3.90	SL449	1.60	2102-2	3.75	74151	2.20
CD4052	2.25	LM372H	7.50	SL610C	7.25	2513N	17.50	74153	1.95
CD4053	2.25	LM372N	4.50	SL612C	7.25	S1883		74145	3.20
CD4066	1.45	LM373N	4.70	SL613C	12.50	S50242	15.00	74157	2.20
CD4068	.55	LM374N	4.90	SL620C	9.50			74160	2.75
CD4069	.60	LM375N	4.90	SL621C	9.50	7805CP	2.90	74164	2.90

In some instances pin for pin substitutes will be supplied.

SEMICONDS		BC549C	.55						
AC125	1.80	BC559	.55	MPF102	.65	2N3053	1.20	2N5458	MPF104
AC126	1.80	BC639	1.20	MPF103	.85	2N3054	1.70	2N5459	MPF105
AC127	1.80	BC640	1.20	MPF104	1.10	2N3055	1.35	2N5485	MPF106
AC128	1.80	BD131	1.20	MPF105	.65	2N3564	.65	2N5590	MPF603
AC132	1.50	BD132	1.60	MPF196	1.15	2N3565	.55	2N5591	11.30
AC187	1.50	BD139	1.20	MPF121	1.60	2N3566	.95	2N6027	1.35
AC188	1.50	BD140	1.20	MRF603	6.90	2N3568	.95	2N6084	21.00
AD149	2.60	BD237	1.80	TIP31C	1.20	2N3569	.50	BA102	.80
AD161/62	4.50	BD238	1.80	TIP32C	1.30	2N3638	.55	OA47	.60
AS322	.18	BD437	2.80	TIP120	3.20	2N3638A	.60	OA90	.35
AT118	2N301	BD438	2.80	TIP125	3.30	2N3642	.55	OA91	.35
ASY17	2.65	BF173	1.25	TIP141	4.70	2N3643	.55	5082-2800	3.20
BC107	.35	BF180	1.20	TIP2955	1.70	2N3694	.65	40440	2N3731
BC108	.35	BF194	.85	TIP3055	1.70	2N3731	5.95	40637A	2.85
BC109	.35	BF200	1.30	TT800	2N4037	2N3819	1.35	40673	1.95
BC177	.40	BFY50	1.20	TT801	1.20	2N3866	2.75	40822	2.90
BC178	.40	BFY51	1.50	2N301	2N2869	2N4037	1.25	40841	1.90
BC179	.40	BPX25	4.90	2N706A	1.20	2N4249	.65	BZX61	.75
BC182	.40	BSX19	.75	2N918	1.60	2N4250	.65	BZX70	1.50
BC212	.50	BU126	3.85	2N2222A	1.20	2N4355	.65	BZY91	12.50
BC327	.55	MFE131	1.95	2N2646	2.50	2N4356	.65	PA40	5.85
BC337	55	MJ802	8.90	2N2869	2.70	2N4360	.95	PB60	6.50
BC547	.55	MJ2955	2.60	2N904A	1.50	2N5245	.75	MEL12	1.40
BC548	.55	MJ4502	8.90	2N2905	1.20	2N5457	MPF103	FCD820	1.90

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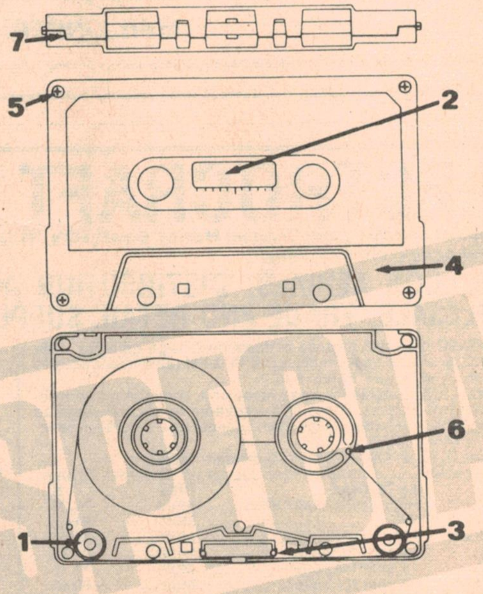

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C45LN	$7.80 78c ea.	$14.80 74c ea.	$34.00 68c ea.	$63.00 63c ea.
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–8000 Hz	dB	+3	+3	+3
Output level for H3=1%	dB	+9	+9	+6
Modulation noise ratio	dB	60	60	55
Stability at 10 kHz	dB	±0.3	±0.4	±0.6

***Referenced to Philips HU 715/11*

Pyral **Cobalt** Cassettes

		C60/C90
Reference-level (RL)	mM/mm	25
Output level at:**		
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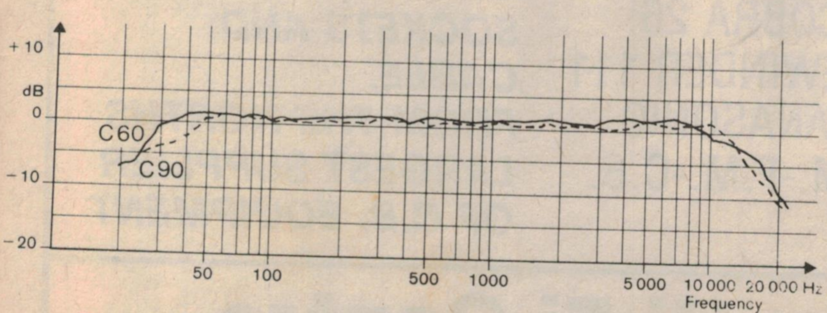
–1000	dB	+1
–8000	dB	+0.5
Output level for H3=5% (OL)	dB	+5
Noise level	dB	65.5
Stability at 8kHz	dB	±0.4

***The reference tape is a DIN tape 4.75*



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MORE ON VCT

In the January 1977 issue of ETI Ron Harris reviewed the recent development of the Voltage-Current Transactor (VCT), perhaps the most important device innovation of recent years for not only is the VCT expected to perform all the functions we now expect of the op-amp but to perform them either better or with fewer additional components.

The earlier article briefly covered the VCT's development and its terminal properties, together with basic circuit applications. This article describes the VCT's internal functioning. It has been written for ETI by Dr. J.E. Morris of the Department of Physics, Victoria University of Wellington, New Zealand.

THE CIRCUIT SYMBOL for the VCT is shown in Fig 1 along with the necessary bias supply and an external resistor R which determines terminal gain. The name "voltage-current transactor" is derived from the translation of differential input voltage into a proportional output current.

As with the conventional op-amp, the input impedance is made as high as possible to minimise loading of any practical source of input voltage. but the main difference between the VCT and an op-amp lies in the output port. As a current source rather than one of voltage, the port impedance is high rather than low. Furthermore, whereas the op-amp output signal is usually single-ended and referenced to ground, the VCT output is completely floating.

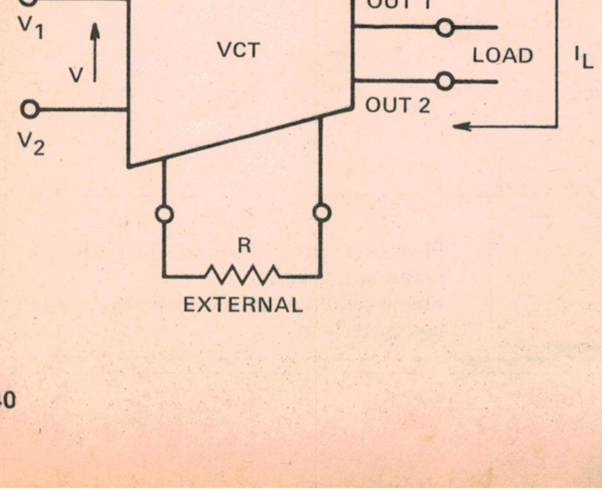

Fig. 1. VCT symbol and external connections.

The VCT is thus a true four terminal device and either terminal of either port may be used as a common point. It will also be apparent from Fig. 1. that there is no external feedback element involved in a simple amplification application.

The internal circuit is shown in Fig. 2. and as explained in this article there is no overall feedback concealed within the unit. With no feedback, there can be no feedback stability problems and thus a major headache of op-amp design vanishes.

VCT Circuit

Modern IC's are generally very complex and involve many functional blocks. At first glance a circuit diagram often appears to have more relevance as a design for a maze than as a sensible means of serving these required electronic functions. The trick is to identify the functional blocks. Once their patterns are recognized, circuit operation may be deduced. For example it is obvious that the VCT is essentially symmetrical about the centre, so only one side need be considered in detail. And the input transistors (Q_1 Q_2 on side 1) clearly form a Darlington pair and may be regarded as a single composite transistor (Q_D say) in any simplified analysis.

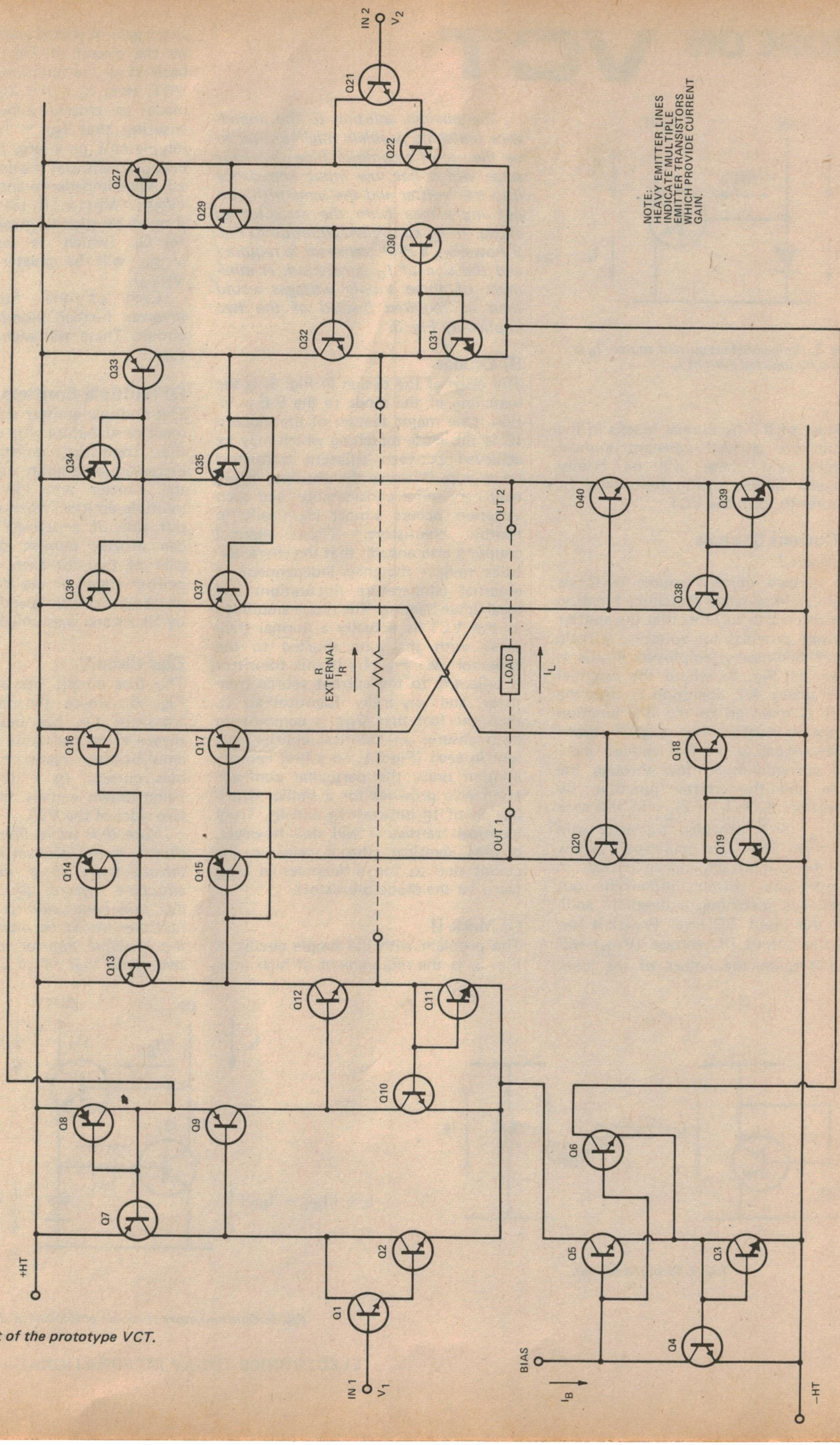

Fig. 2. Internal circuit of the prototype VCT.

MORE ON VCT

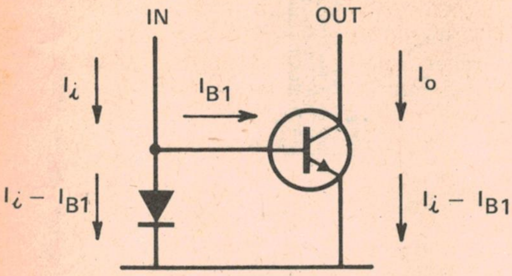

Fig. 3. Basic constant current source. I_o is fixed by injected current I_i.

Most of the functional blocks in the circuit are derived constant current sources and these will be briefly reviewed before seeing how they fit together to form the VCT.

IC Current Sources

A) Mark I

The derived current source performs a similar impedance matching function with respect to currents that the emitter follower provides for voltages. A basic circuit commonly employed in ICs is shown in Fig. 3. where the essential requirement for operation is that the diode is matched to the B-E junction of the transistor. For a given diode voltage equal to the B-E voltage, identical currents must flow through the diode and the emitter junction. By inspection, $I_0 = I_i - 2I_{B1}$ in this case and $I_o \approx I_i$ provided transistor gain β is high. The input impedance is low and the output impedance is high to provide the current in/current out impedance matching required. In addition the input DC level (V_{BE}) is low and the output DC voltage (V_{CB}) will depend upon the nature of the load.

The obvious solution to the impedance matching problem might appear to be the use of a common-base transistor stage which has low input impedance into the emitter and the same high output impedance from the collector as above. In an equivalent situation to Fig. 3 however, a PNP transistor is required and the sign of I_o is reversed. A minimum of three supply voltages would then be required instead of the two implied by Fig. 3.

B) Diodes

The crux of the design in Fig. 3. is the matching of the diode to the B-E junction. One major feature of the modern IC is the close matching which may be achieved between adjacent transistors on a chip. Whereas the absolute values may vary quite considerably, and such variation occurs almost identically in nearby transistors. Tight thermal coupling also ensures that the characteristics remain matched independent of external temperature fluctuations and local Joule heating. The diode employed in the VCT is actually a normal transistor with the base shorted to the collector (see Fig. 4.) If this transistor is adjacent to the current source transistor and plysically identical to it, then the fact that V_{BE} is common to both ensures an identical emitter current in each (Fig 3.). To a first approximation only, the particular configuration also provides for a similar distribution of I_E between I_B and I_C. Truly identical transistors will not, however, possess identical current gains in the circuit due to the differences in V_{CB} (zero for the diode transistor).

C) Mark II

The problem with the simple circuit of Fig. 3. is the requirement of high transistor gain. A partial solution is provided by the circuit of Fig. 5. which is the basis of all the functional blocks of the VCT. Here $I_o = I_i + 2(I_{BI} - I_{B2})$ and is made to closely approximate I_i by ensuring that $I_{BI} \approx I_{B2}$ rather than relying only on a large β. Note that the improvement is at the cost of an increased input impedance and DC input level ($V_{BEi} + V_{BEo}$). If $I_{BI} = I_{B2}$ exactly, β must be slightly greater for Q_o than for Q_i (which is reasonable since V_{CBo} will be greater than $V_{CBi} = V_{BEo}$).

Each of the functional blocks involves further modification of this circuit. These will each be described in turn.

D) Multiple Emitters

The multiple emitter structure has been mentioned before. All it means is that the transistor emitter current is increased for a given V_{BE} by increasing the emitter area. In this way the multiple emitter, when used in the output side of a derived current source, can provide current gain. A current gain of two for each of the multiple emitter stages in the VCT leads to the prototype device specifications quoted by Harris and is assumed below.

Bias Circuit

The bias circuit has been redrawn in Fig. 6. where the multiple emitter transistor Q_3 has been split and is shown as two separate diodes. Current amplification leads to the defined bias current $I_B = (V_S - 2V_{BE})/R_B$ being drawn equally from each of the two sides of the VCT.

Note that while the total symmetry shown in the diagram implies that the introduction of a multiple emitter structure requires β_5, β_6 to be twice β_4, this conclusion is misleading. In fact one would be more likely to vary the multiple emitter area slightly off two, such that (i) all β's were approx-

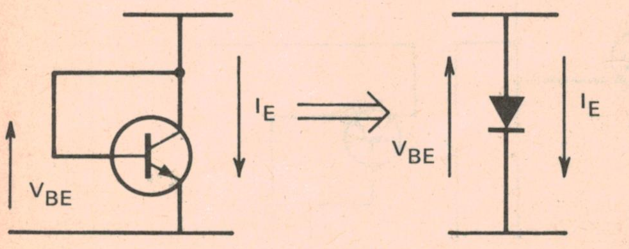

Fig. 4. IC diode format.

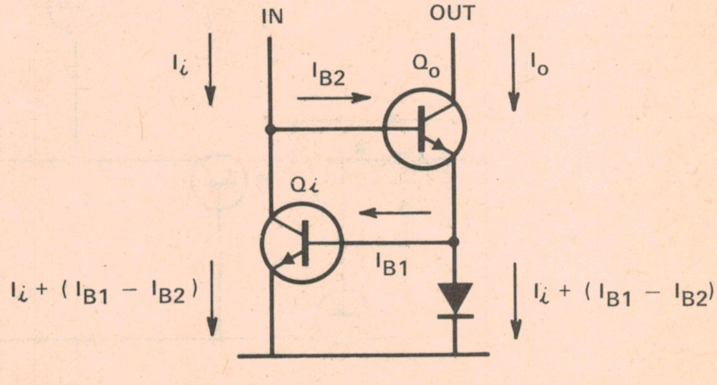

Fig. 5. Constant current source employed in the VCT.

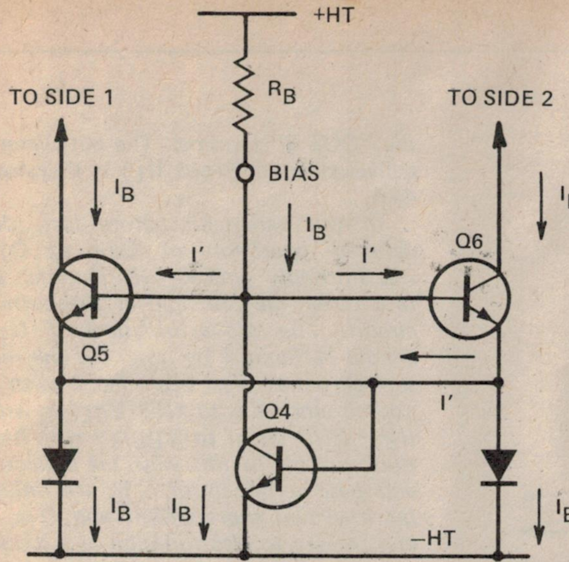

Fig. 6. Bias circuit as an example of the multiple-emitter diode.

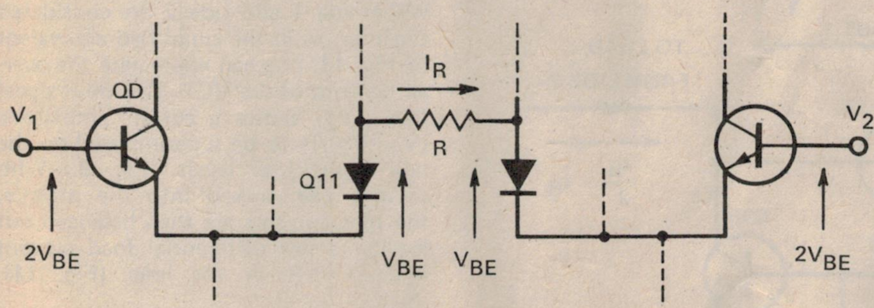

Fig. 7. Simplified view of the differential input circuit.

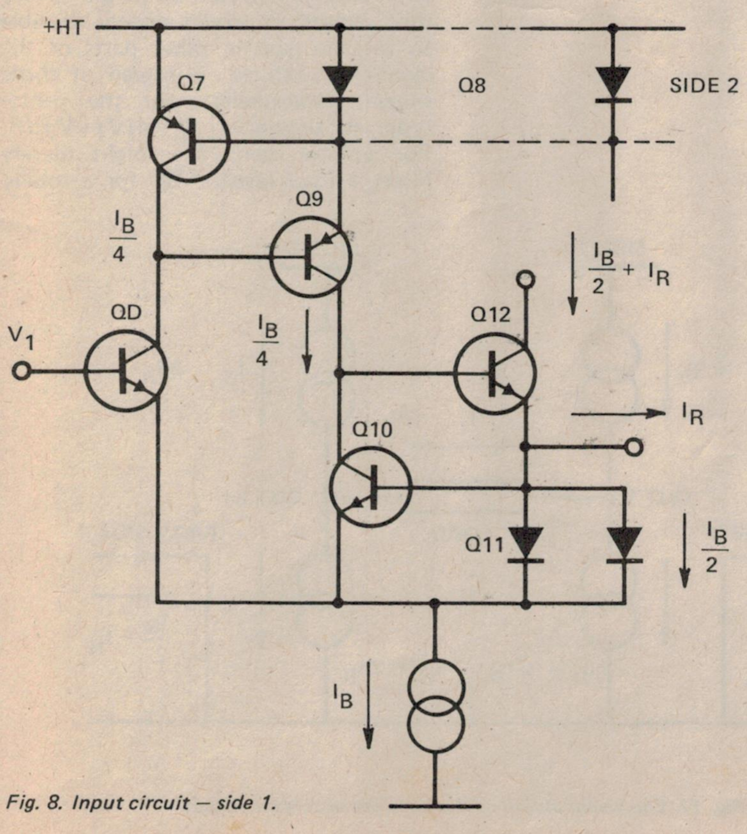

Fig. 8. Input circuit – side 1.

imately equal as before (ii) diode currents become $I_B + \frac{1}{2}I'$, and (iii) the base current of Q_4 reverts to $(\frac{1}{2}I') + (\frac{1}{2}I')$.

Differential Input

It should be clear by now that the VCT relies upon defined current sourcing and multiple emitter current amplification to function. The input signal, however, is defined as a differential voltage ($V_1 - V_2$) and must be converted to a proportional current. This is the purpose of the external resistor R as shown by the simplified view of Fig. 7. where I_R is clearly $(V_1 - V_2)/R$ provided symmetry is maintained. (Q_D is the Darlington combination Q_1 and Q_2,; Q11 functions as a diode.)

It will be seen shortly that the existence of a finite I_R upsets the symmetry – in fact this is how the circuit functions. So once again, our ideal is not quite possible since the diodes carry different currents at slightly different voltages. In fact $I_R \gtrsim (V_1 - V_2)/R$.

The next step is to see how I_R is converted to an output current.

Input Circuit

The input section of one side of the VCT is redrawn in Fig. 8. Q_8 services both sides of the circuit and has been split in the diagram. Assume for the moment that some current I_x flows down through Q_7 and then the Darlington Q_D. The Q_7,Q_8,Q_9 current sourcing circuit requires I_x to also flow through Q_9 and Q_{10}. Similarly Q_{11} should draw $2I_x$ due to the double emitter. The total $4I_x$ must equal the bias current I_B and hence the currents are as shown with Q_{12} also carrying I_B. The principle of this input circuit is summarised for reinforcement in Fig. 9. which should be compared with Figs. 7 and 8.

It has already been stated that V_{CB} of the source output transistors will vary under operating conditions and

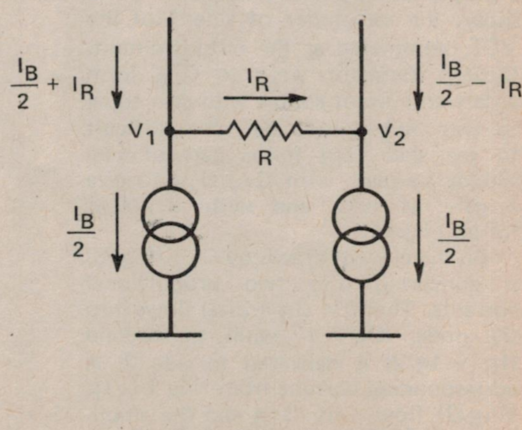

Fig. 9. Equivalent input circuit.

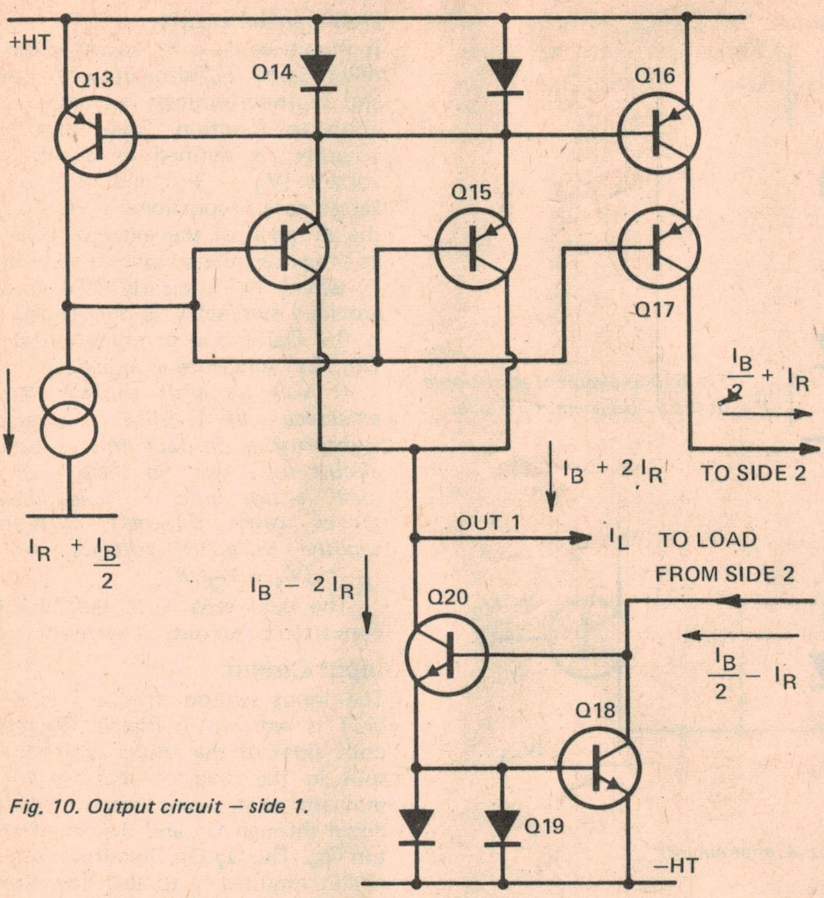

Fig. 10. Output circuit — side 1.

cause deviations from ideal behaviour due to resultant in β. In Q_{12} the base current I_{B12} (assuming constant β to first order) can no longer equal I_{B10}. Current source operation must therefore deteriorate under operational conditions.

Output Circuit

The next step is to determine how the input signal current I_R is translated into a proportional floating output. Fig. 10 shows the remainder of side 1 of the VCT, designated as the output circuit. Clearly transistors Q_{18} to Q_{20} form a derived current source with gain equal to two. But it may be more difficult to see that Q_{13} forms part of two similar sources: with Q_{14}/Q_{15} to give a gain of two, and with Q_{16}/Q_{17} for unity gain.

So the current drawn by Q_{12} (Fig. 8) is converted into two proportional currents. The first $(I_B + 2I_R)$ flows into the node "OUT 1" while the second $(I_R + I_B/2)$ is delivered to side 2. A corresponding current from side 2 $(-I_R + I_B/2)$ flows into Q_{18} and the amplified signal $(I_B - 2I_R)$ is drawn from the "OUT 1" terminal. The net current delivered to the load (I_L) is therefore $4I_R$.

In the paragraph before last, the detailed operation of Q_{14} to Q_{17} was hurriedly glossed over in order to first cover the principle of the output circuit. The diode function of Q_{14} should be familiar by now, but the reason Q_{15} has also been made with a double emitter is to keep $V_{BE})_{15}$ with $(I_B + 2I_R)$ equal to $V_{BE})_{17}$ with half that current. In this way, the collector and base terminals of Q_{16} are linked by a virtual short circuit and Q_{16} is constrained to also function as a diode.

Overall Principle

When side 1 and side 2 are considered together, as in the simplified equivalent of Fig. 11, one can appreciate the overall concept of the VCT. The input signal $(V_1 - V_2)$ causes a current imbalance $(V_1-V_2)/R$ to be superimposed on the null input bias levels (Fig. 9.) With current gain mixed into the process, the bias currents are then balanced out leaving a net differential load current $4(V_1-V_2)/R$ in the load (Fig. 11).

Device Properties

Each multiple emitter in the prototype VCT has been assumed to give a gain of two. Clearly, it would be simple to vary this; indeed it would appear feasible to provide gain in other parts of the circuit as well as or instead of those shown. Nevertheless, for the prototype as shown, $I_L = 4(V_1-V_2)/R$. For voltage gain, one might merely insert a load resistor R_L for a totally

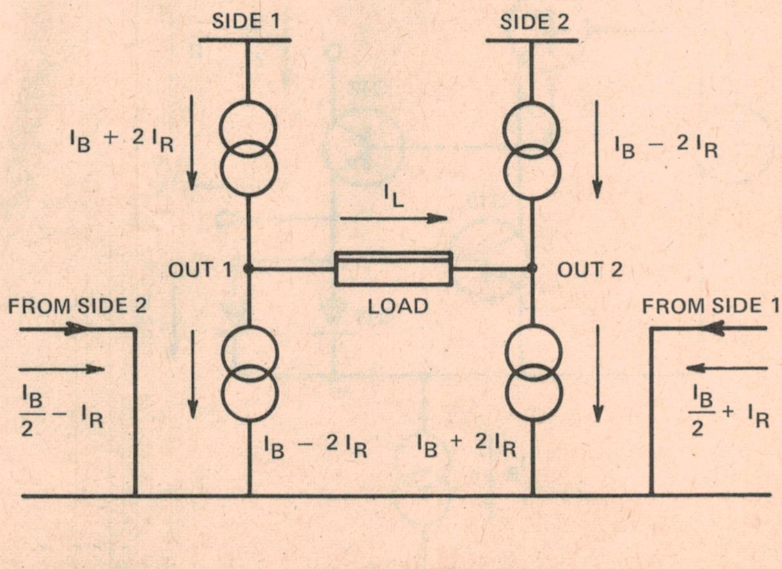

Fig. 11. Equivalent circuit of the differential current output.

floating output gain $4R_L/R$. Other elementary circuit configurations have been described by Harris.

The absolute linear range of the VCT is restricted in both current and voltage.

Transistor cutoff when $2I_R = I_B$ (see Fig. 10) limits output current $I_L = 4I_R$) to a maximum of $\pm 2I_B$, I_B being set by the circuit designer. Either output current or load is also limited by load voltage and the onset of saturation in the output transistors, i.e. the load voltage $I_L R_L$ may not exceed the total power supply range minus $4V_{BE}$. For + 15V supplies and 10mA bias current the load impedance limit is 1k4 if the full output current range is to be available. Note also that wide signal excursions from the symmetrical design bias point lead to loss of linearity, since V_{CB}'s of the current source output transistors are moved off bias values causing β to also shift. The need to maintain V_{CB} and β close to design values also limits the acceptable power supply variation – about 10 to 15% according to Harris. These figures would suggest that linearity may be seriously degraded by voltage swing well before the saturation limit is reached.

High input impedance R_{in} is a fundamental requirement of the VCT concept and is the reason for the use of Darlington inputs. To the grossest of approximations, small signal R_{in} (= $\beta_1 \beta_2 R/\beta_{10}$) is critically dependent upon the input stage current gain and maximising it leads to a whole series of tradeoffs, (e.g. R. should be low for high transconductance, β_{10} high for current source operation).

The differential output impedance works out to be roughly $1/h_{oe}$ (h_{oe} = $\partial I_c / \partial V_{CE}$ for constant I_B) and naturally the output transistors must have high collector impedances. Both input and output circuits should function near ideally, however, provided they are not unduly pushed by the circuit designer's concept of reasonable source or load impedances!

Common mode rejection ratio and required offset will both depend upon the degree of symmetry attainable in mass production but there is no reason to be pessimistic about them. High slew rates have been reported and are undoubtedly due to the fact that currents vary in only half of the circuit transistors and that the signal only proceeds sequentially through about half of these.

Conclusion

The main objective of this article has been the explanation of the principles of circuit operation. A secondary aim was to point out some unwanted second order effects and practical limitations. Such limitations occur in all devices and must not be ignored by either the designer or user.

The immediate question is whether the VCT will survive through to production or remain just another bright idea. Simplicity is a major advantage to any technological innovation and despite the plethora of transistors, the VCT is very simple in principle. Furthermore its implementation will rely totally on existing technology – its future looks bright.

I should like to thank my students whose curiosity and questions about the VCT has led directly to this article.

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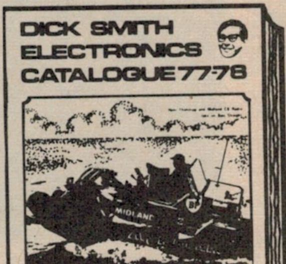

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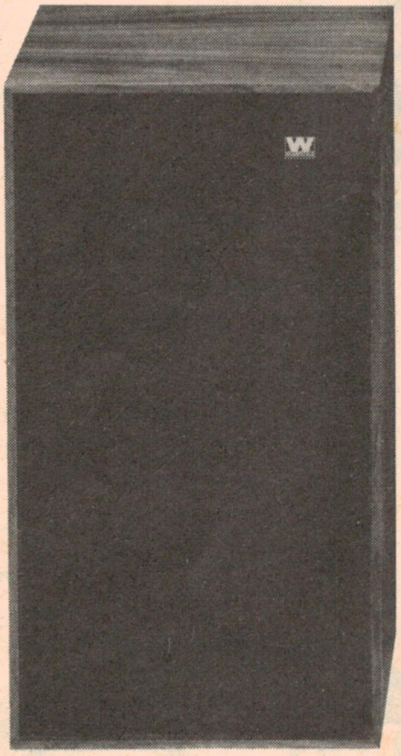

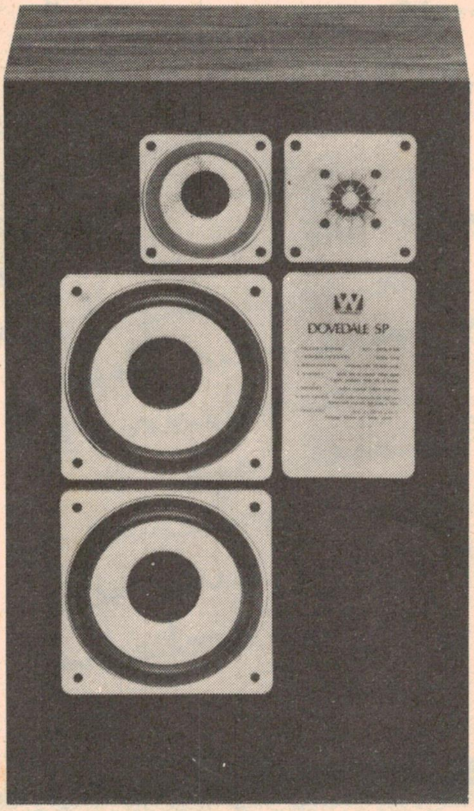

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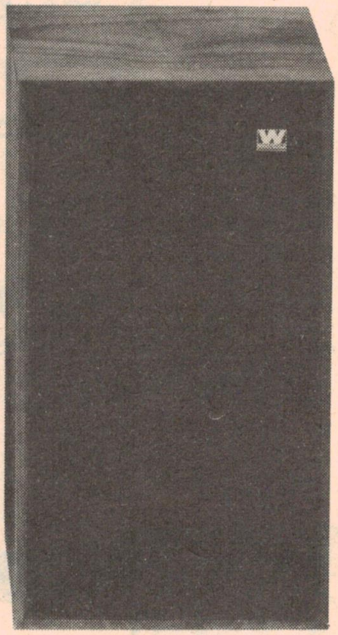

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THE 741 COOKBOOK

OPERATIONAL AMPLIFIERS (OP-AMPS) CAN be simply described as high-gain direct-coupled voltage amplifier 'blocks' that have a single output terminal but have both inverting and non-inverting input terminals. Op-amps can readily be used as inverting, non-inverting, and differential amplifiers in both a.c. and d.c. applications, and can easily be made to act as oscillators, tone filters, and level switches, etc.

Op-amps are readily available in integrated circuit form, and as such act as one of the most versatile building blocks available in electronics today. One of the most popular op-amps presently available is the device that is universally known as the "741" op-amp In this article we shall describe the basic features of this device, and show a wide variety of practical circuits in which it can be used.

BASIC OP-AMP CHARACTERISTICS AND CIRCUITS

In its simplest form, an op-amp consists of a differential amplifier followed by offset compensation and output stages, as shown in Fig. 1a. The differential amplifier has inverting and non-inverting input terminals, a high-impedance (constant current) tail to

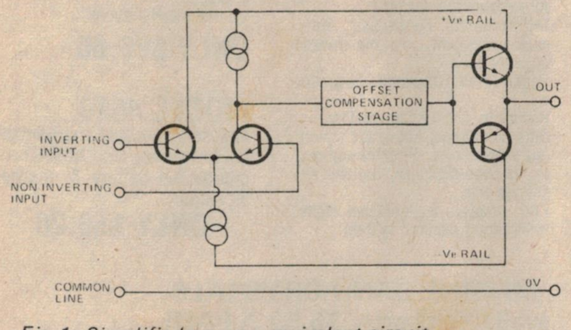

Fig. 1a Simplified op-amp equivalent circuit.

give a high input impedance and a high degree of common mode signal rejection. It also has a high-impedance (constant current) load to give a high degree of signal voltage stage gain.

The output of the differential amplifier is fed to a direct-coupled offset compensation stage, which effectively reduces the output offset voltage of the differential amplifier to zero volts under quiescent conditions, and the output of the compensation stage is fed to a simple complementary emitter follower output stage, which gives a low output impedance.

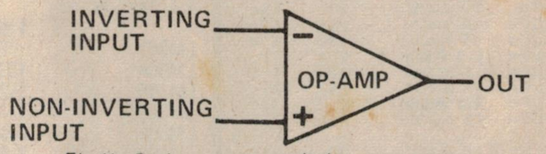

Fig.1b Basic op-amp symbol.

LINES OF SUPPLY

Op-amps are normally powered from split power supplies, providing +ve, −ve, and common (zero volt) supply rails, so that the output of the op-amp can swing either side of the zero volts value, and can be set at a true zero volts (when zero differential voltage is applied to the circuits input terminals.)

The input terminals can be used independently (with the unused terminal grounded) or simultaneously, enabling the device to function as an inverting, non-inverting, or differential amplifier. Since the device is direct-coupled throughout, it can be used to amplify both a.c. and d.c. input signals. Typically, they give basic low-frequency voltage gains of about 100 000 between input and output, and have input impedances of 1M or greater at each input terminal.

Fig. 1b shows the symbol that is commonly used to represent an op-amp, and 1c shows the basic supply connections that are used with the device. Note that both input and output signals of the op-amp are referenced to the ground or zero volt line.

SIGNAL BOX

The output signal voltage of the op-amp is proportional to the DIFFERENTIAL signal between its two input terminals, and is given by

$$e_{out} = A_0(e_1 - e_2)$$

where A_o = the open-loop voltage gain of the op-amp (typically 100 000).

e_1 = signal voltage at the non-inverting input terminal.

e_2 = signal voltage at the inverting input terminal.

Thus, if identical signals are simultaneously applied

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ELECTROLYTICS:

Value	Voltage	1 off	25 up
1 μFd	6.3 Axial	15c	13c
2.2 μFd	25 p.c.b.	10c	8c
3.3 μFd	25 p.c.b.	10c	8c
4.7 μFd	10 p.c.b.	10c	8c
4.7 μFd	25 p.c.b.	10c	8c
22 μFd	10 p.c.b.	10c	8c
22 μFd	50 p.c.b.	17c	15c
25 μFd	16 p.c.b.	10c	8c
33 μFd	6.3 p.c.b.	11c	9c
33 μFd	16 p.c.b.	12c	10c
47 μFd	10 p.c.b.	14c	12c
47 μFd	25 p.c.b.	16c	14c
47 μFd	50 p.c.b.	17c	15c
100 μFd	10 p.c.b.	16c	13c
100 μFd	25 p.c.b.	18c	15c
220 μFd	6.3 Axial	20c	17c
220 μFd	16 p.c.b.	20c	17c
220 μFd	35 p.c.b.	26c	22c
470 μFd	6.3 Axial	25c	22c
470 μFd	25 p.c.b.	25c	22c
			10 up
1000 μFd	10 Axial	38c	35c
1000 μFd	16 p.c.b.	40c	36c
1000 μFd	25 p.c.b.	52c	47c
1000 μFd	35 p.c.b.	52c	47c
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7404	40c	35c
7408	40c	35c
7410	40c	35c
7420	40c	35c
7430	40c	35c
7447	$1.50	$1.40
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7454	40c	35c
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7492	80c	75c
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C/MOS

	1 off	10 up
4000	40	35
4001	40	35
4002	40	35
4006	2-50	2-25
4007	40	35
4008	2-75	2-50
4009	80	70
4011	45	40
4012	40	35
4013	1-00	90
4014	2-25	2-05
4016	85	75
4017	2-25	2-05
4018	2-50	2-25
4021	2-30	2-10
4022A	1-90	1-70
4023A	45	40
4024	1-35	1-20
4027A	1-00	90
4028A	1-90	1-70
4030A	80	70

LINEAR

	1 off	10 up
LM301	70	60
LM304	1-30	1-20
LM305	1-20	1-10
LM307	70	60
LM308	2-30	2-10
LM309K	2-80	2-60
LM319	2-80	2-60
LM324	3-20	3-00
LM339	3-20	3-00
LM377	2-80	2-50
LM380	1-50	1-35
LM382	2-45	2-30
LM3900	1-50	1-25
LM555	85	75
LM566	4-50	4-30
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LM741	45	40
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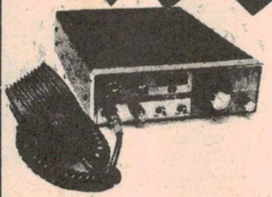

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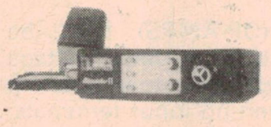

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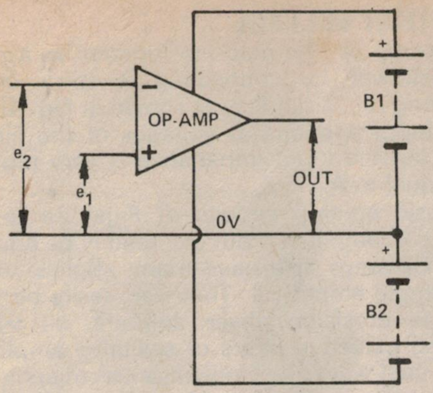


Fig. 1c Basic supply connections of an op-amp.

to both input terminals, the circuit will (ideally) give zero signal output. If a signal is applied to the inverting terminal only, the circuit gives an amplified and inverted output. If a signal is applied to the non-inverting terminal only, the circuit gives an amplified but non-inverted output.

By using external negative feedback components, the stage gain of the op-amp circuit can be very precisely controlled.

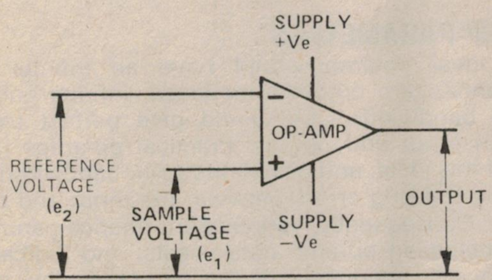


Fig. 2a Simple differential voltage comparator circuit.

TRANSFER REQUEST

Fig. 2a shows a very simple application of the op-amp. This particular circuit is known as a differential voltage comparator, and has a fixed reference voltage applied to the inverting input terminal, and a variable test or sample voltage applied to the non-inverting terminal. When the sample voltage is more than a few hundred microvolts above the reference voltage the op-amp output is driven to saturation in a positive direction, and when the sample is more than a few hundred microvolts below the reference voltage the output is driven to saturation in the negative direction.

Fig. 2b shows the voltage transfer characteristics of the above circuit. Note that it is the magnitude of the differential input voltage that dictates the magnitude of the output voltage, and that the absolute values of input voltage are of little importance. Thus, if a 1V reference is used and a differential voltage of only 200uV is needed to switch the output from a negative to a positive saturation level, this change can be caused by a shift of only 0.02% on a 1V signal applied to the sample input. The circuit thus functions as a precision voltage comparator or balance detector.

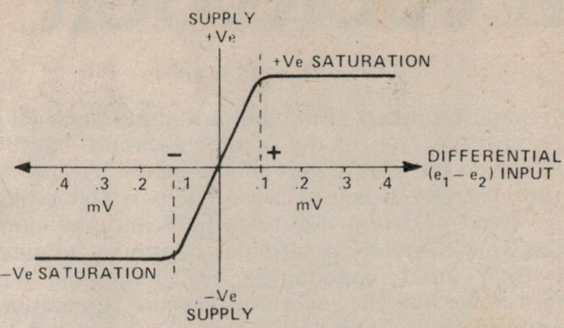


Fig. 2b Transfer characteristics of the differential voltage comparator circuit.

GOING TO GROUND

The op-amp can be made to function as a low-level inverting d.c. amplifier by simply grounding the non-inverting terminal and feeding the input signal to

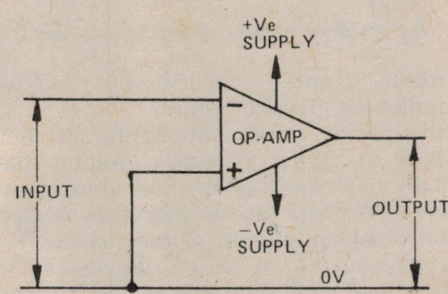


Fig. 3a Simple open-loop inverting d.c. amplifier.

the inverting terminal, as shown in Fig. 3a. The op-amp is used 'open-loop' (without feedback) in this configuration, and thus gives a voltage gain of about 100 000 and has an input impedance of about 1M. The disadvantage of this circuit is that its parameters are dictated by the actual op-amp, and are subject to considerable variation between individual devices.

CLOSING LOOPS

A far more useful way of employing the op-amp is to use it in the closed-loop mode, i.e., with negative feedback. Fig. 3b shows the method of applying negative feedback to make a fixed-gain inverting d.c. amplifier. Here, the parameters of the circuit are controlled by feedback resistors R_1 and R_2. The gain, A of the circuit is dictated by the ratios of R_1 and R_2, and equals R_2/R_1.

The gain is virtually independent of the op-amp characteristics, provided that the open-loop gain (A_o) is large relative to the closed-loop gain (A). The input impedance of the circuit is equal to R_1, and again is virtually independent of the op-amp characteristics.

741 COOKBOOK

It should be noted at this point that although R_1 and R_2 control the gain of the complete circuit, they have no effect on the parameters of the actual op-amp, and the full open-loop gain of the op-amp is still available between its inverting input terminal and the output. Similarly, the inverting terminal continues to have a very high input impedance, and negligible signal current flows into the inverting terminal. Consquently, virtually all of the R_1 signal current also flows in R_2, and

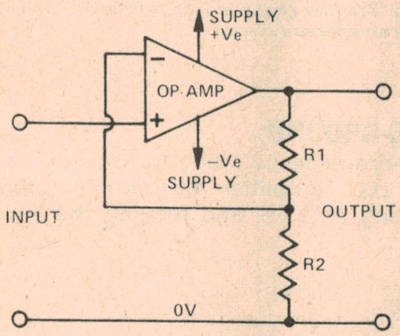


Fig. 4a Basic non-inverting d.c. amplifier

signal currents i_1 and i_2 can be regarded as being equal, as indicated in the diagram.

Since the signal voltage appearing at the output terminal end of R_2 is A times greater than that appearing at the inverting terminal end, the current flowing in R_2 is A times greater than that caused by the inverting terminal signal only. Consequently, R_2 has an apparent value of R_2/A when looked at from its inverting terminal end, and the R_1-R_2 junction thus appears as a low-impedance VIRTUAL GROUND point.

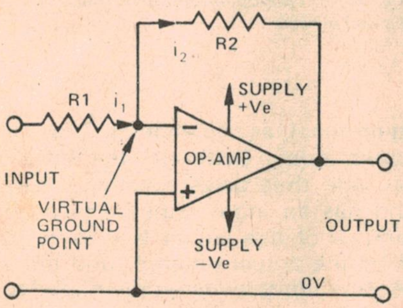


Fig. 3b Basic closed-loop inverting d.c. amplifier.

INVERT OR NOT TO INVERT . . .

It can be seen from the above description that the Fig. 3b circuit is very versatile. Its gain and input impedance can be very precisely controlled by suitable choice of R_1 and R_2, and are unaffected by variations in the op-amp characteristics. A similar thing is true of the non-inverting d.c. amplifier circuit shown in Fig. 4a. In this case the voltage gain is equal to $(R_1+R_2)/R_2$ and the input impedance is approximately equal to (A_0/A)Zin where Zin is the open-loop input impedance of the op-amp. A great advantage of this circuit is that it has a very high input impedance.

FOLLOW THAT VOLTAGE

The op-amp can be made to function as a precision voltage follower by connecting it as a unity-gain non-inverting d.c. amplifier, as shown in Fig. 4b. In this case the input and output voltages of the circuit are identical, but the input impedance is very high and is roughly equal to $A_0 \times Z_{in}$.

The basic op-amp circuits of Figs. 2a to 4b are shown as d.c. amplifiers, but can readily be adapted for a.c. use. Op-amps also have many applications other than as simple amplifiers. They can easily be made to function as precision phase splitters, as adders or subtractors, as active filters or selective amplifiers, as precision half-wave or full-wave rectifiers, and as oscillators or multivibrators, etc.

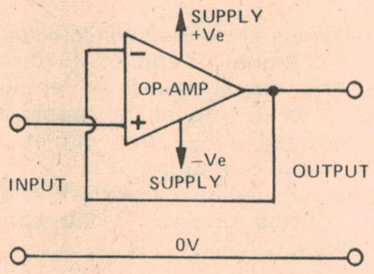


Fig. 4b Basic unity-gain d.c. voltage follower

OP-AMP PARAMETERS

An ideal op-amp would have an infinite input impedance, zero output impedance, infinite gain and infinite bandwidth, and would give perfect tracking between input and output. Practical op-amps fall far short of this ideal, and have finite gain, bandwidth, etc., and give tracking errors between the input and output signals. Consequently, various performance parameters are detailed on op-amp data sheets, and indicate the measure of "goodness" of the particular device. The most important of these parameters are detailed below.

OPEN-LOOP VOLTAGE GAIN, A_0. This is the low-frequency voltage gain occuring directly between the input and output terminals of the op-amp, and may be expressed in direct terms or in terms of dB. Typically, d.c. gain figures of modern op-amps are 100 000, or 100dB.

INPUT IMPEDANCE, Z_{in}. This is the impedance looking directly into the input terminals of the op-amp when it is used open-loop, and is usually expressed in terms of resistance only. Values of 1M are typical of modern op-amps with bi-polar input stages, while F.E.T. input types have impedances of a million meg or greater.

OUTPUT IMPEDANCE, Z_0. This is the output impedance of the basic op-amp when it is used open-loop, and is usually expressed in terms of resistance only. Values of a few hundred ohms are typical of modern op-amps.

INPUT BIAS CURRENT, I_b. Many op-amps use bipolar transistor input stages, and draw a small bias current from the input terminals. The magnitude of this current is denoted by I_b, and is typically only a fraction of a microamp.

741 COOKBOOK

SUPPLY VOLTAGE RANGE, V_s. Op-amps are usually operated from two sets of supply rails, and these supplies must be within maximum and minimum limits. If the supply voltages are too high the op-amp may be damaged, and if the supply voltages are too low the op-amp will not function correctly. Typical supply limits are $\pm 3V$ to $\pm 15V$.

INPUT VOLTAGE RANGE, $V_{i(max)}$. The input voltage to the op-amp must never be allowed to exceed the supply line voltages, or the op-amp may be damaged. $V_{i(max)}$ is usually specified as being one or two volts less than v_s.

OUTPUT VOLTAGE RANGE, $V_{o(max)}$. If the op-amp is over driven its output will saturate and be limited by the available supply voltages, so $V_{o(max)}$ is usually specified as being one or two volts less than V_s.

DIFFERENTIAL INPUT OFFSET VOLTAGE, V_{io}. In the ideal op-amp perfect tracking would exist between the input and output terminals of the device, and the output would register zero when both inputs were grounded. Actual op-amps are not perfect devices, however, and in practice slight imbalances exist within their input circuitry and effectively cause a small offset or bias potential to be applied to the input terminals of the op-amp. Typically, this DIFFERENTIAL INPUT OFFSET VOLTAGE has a value of only a few millivolts, but when this voltage is amplified by the gain of the circuit in which the op-amp is used it may be sufficient to drive the op-amp output to saturation. Because of this, most op-amps have some facility for externally nulling out the offset voltage.

COMMON MODE REJECTION RATION, c.m.r.r. The ideal op-amp produces an output that is proportional to the difference between the two signals applied to its input terminals, and produces zero output when identical signals are applied to both inputs simultaneously, i.e., in common mode. In practical op-amps, common mode signals do not entirely cancel out, and produce a small signal at the op-amps output terminal. The ability of the op-amp to reject common mode signals is usually expressed in terms of common mode rejection ratio, which is the ratio of the op-amps gain with differential signals to the op-amps gain with common mode signals. C.m.r.r. values of 90dB are typical of modern op-amps.

TRANSITION FREQUENCY, f_T. An op-amp typically gives a low-frequency voltage gain of about 100dB, and in the interest of stability its open-loop frequency response is tailored so that the gain falls off as the frequency rises, and falls to unity at a transition frequency denoted f_T. Usually, the response falls off at a rate of 6dB per octave or 20dB per decade. Fig. 5 shows the typical response curve of the type 741 op-amp, which has an f_T of 1MHz and a low frequency gain of 100dB.

Note that, when the op-amp is used in a closed-loop amplifier circuit, the bandwidth of the circuit depends on the closed-loop gain If the amplifier is used to give a gain of 60dB its bandwidth is only 1kHz, and if it is used to give a gain of 20dB its bandwidth is 100kHz. The f_T figure can thus be used to represent a gain-bandwidth product.

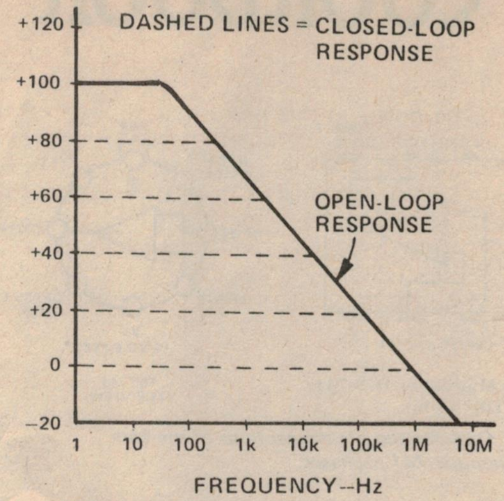


Fig. 5 Typical frequency response curve of the 741 op-amp.

	PARAMETER	741 VALUE
A_o	OPEN-LOOP VOLTAGE GAIN	100dB
Z_{IN}	INPUT IMPEDANCE	1M
Z_o	OUTPUT IMPEDANCE	150R
I_b	INPUT BIAS CURRENT	200nA
$V_{s\,(MAX)}$	MAXIMUM SUPPLY VOLTAGE	±18V
$V_{i\,(MAX)}$	MAXIMUM INPUT VOLTAGE	±13V
$V_{o\,(MAX)}$	MAXIMUM OUTPUT VOLTAGE	±14V
V_{io}	DIFFERENTIAL INPUT OFFSET VOLTAGE	2mV
c.m.m.r.	COMMON MODE REJECTION RATIO	90dB
F_T	TRANSITION FREQUENCY	1MHZ
S	SLEW RATE	1V/uS

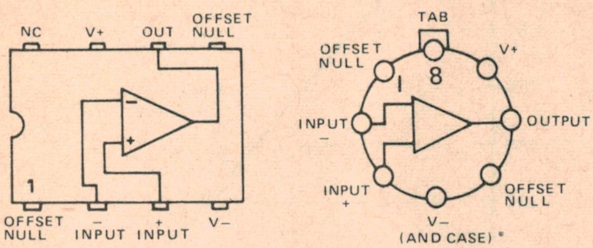
Table 1 Typical characteristics of the 741 op-amp.

SLEW RATE. As well as being subject to normal bandwidth limitations, op-amps are also subject to a phenomenon known as slew rate limiting, which has the effect of limiting the maximum rate of change of voltage at the output of the device. Slew rate is normally specified in terms of volts per microsecond, and values in the range 1V/us to 10V/us are common with most popular types of op-amp. One effect of slew rate limiting is to make a greater bandwidth available to small output signals than is available to large output signals.

THE 741 OP-AMP.

Early types of i.c. op-amp, such as the well known 709 type, suffered from a number of design weaknesses. In particular, they were prone to a phenomenon known as INPUT LATCH-UP, in which the input circuitry tended to switch into a locked state if special precautions were not taken when connecting the input signals to the input terminals, and tended to self-destruct if a short circuit were inadvertently placed across the op-amp output terminals. In addition, the op-amps were prone to bursting into unwanted oscillations when used in the linear amplifier mode, and required the use of external frequency compensation components for stability control.

These weaknesses have been eliminated in the type 741 op-amp. This device is immune to input latch-up problems, has built-in output short circuit protection, and does not require the use of external frequency compensation components. The typical performance



8 pin Minidip or DIP 741
(Top View)

T05 741
(TOP VIEW)

Fig. 6 Outlines and pin connections of the two most popular 741 packages.

characteristics of the device are listed in Table 1.

The type 741 op-amp is marketed by most i.c. manufacturers, and is very readily available. Fig. 6 shows the two most commonly used forms of packaging of the device. Throughout this chapter, all practical circuits are based on the standard 8-pin dual-in-line (D.I.L. or DIP) version of the 741 op-amp.

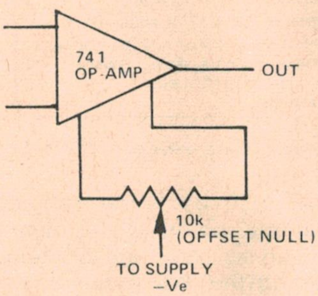


Fig. 7 Method of applying offset nulling to the 741 op-amp.

The 741 op-amp can be provided with external offset nulling by wiring a 10k pot between its two null terminals and taking the pot slider to the negative supply rail, as shown in Fig. 7.

Having cleared up these basic points, let's now go on and look at a range of practical applications of the 741 op-amp.

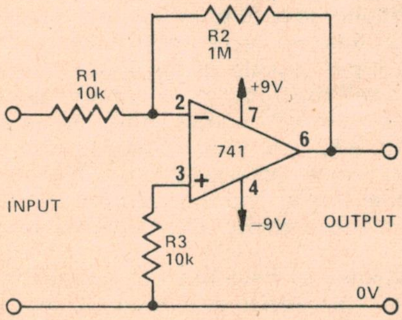


Fig. 8a x100 inverting d.c. amplifier.

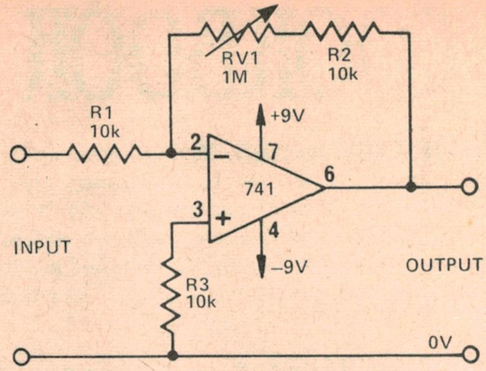


Fig. 8b Variable gain (x1 to x100) inverting d.c. amplifier.

BASIC LINEAR AMPLIFIER PROJECTS. (Figs. 8 to 11).

Figs. 8 to 11 show a variety of ways of using the 741 in basic linear amplifier applications.

The 741 can be made to function as an inverting amplifier by grounding the non-inverting input terminal and feeding the input signal to the inverting terminal. The voltage gain of the circuit can be precisely controlled by selecting suitable values of external feedback resistance. Fig. 8a shows the practical connections of an inverting d.c. amplifier with a pre-set gain of x100. The voltage gain is determined by the ratios of R_1 and R_2, as shown in the diagram.

The gain can be readily altered by using alternative R_1 and/or R_2 values. If required, the gain can be made variable by using a series combination of a fixed and a variable resistor in place of R_2, as shown in the circuit of Fig. 8b, in which the gain can be varied over the range x1 to x100 via R_2.

VARIATIONS

A variation of the basic inverting d.c. amplifier is shown in Fig. 9a. Here, the feedback connection to R_2 is taken from the output of the R_3–R_4 output potential divider, rather than directly from the output of the op-amp, and the voltage gain is determined by the ratios of this divider as well as by the values of R_1 and

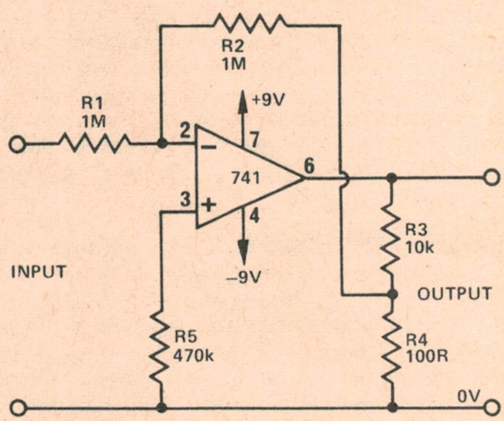


Fig. 9a High impedance x100 inverting d.c. amplifier.

R_2. The important feature of this circuit is that it enables R_1, which determines the input impedance of the circuit, to be given a high value if required, while at the same time enabling high voltage gain to be achieved.

The basic inverting d.c. amplifier can be adapted for

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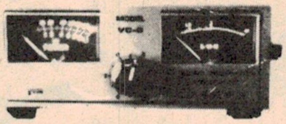

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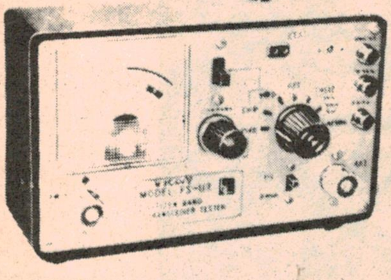

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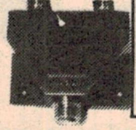

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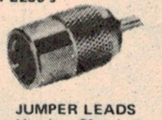

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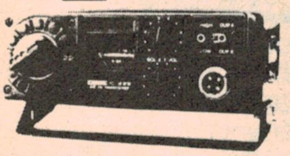

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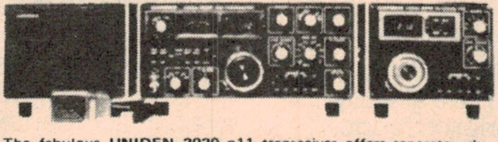

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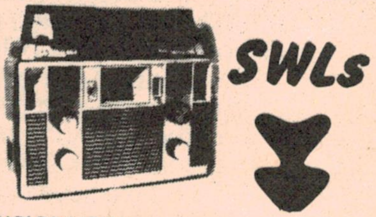

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a.c. use by simply wiring blocking capacitors in series with its input and output terminals, as shown in the x100 inverting a.c. amplifier circuit of Fig. 9b.

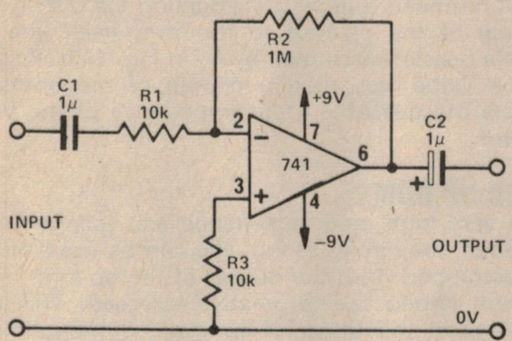

Fig. 9b x100 inverting a.c. amplifier.

NON-INVERTING . . .

The amp can be made to function as a non-inverting amplifier by feeding the input signal to its non-inverting terminal and applying negative feedback to the inverting terminal via a resistive potential divider that is connected across the op-amp output. Fig. 10a shows the connections for making a fixed gain (x100) d.c. amplifier.

The voltage gain of the Fig. 10a circuit is determined by the ratios of R_1 and R_2. If R_2 is given a value of zero the gain falls to unity, and if R_1 is given a value of zero the gain rises towards infinity (but in practice is limited to the open-loop gain of the op-amp). If required, the gain can be made variable by replacing R_2 with a

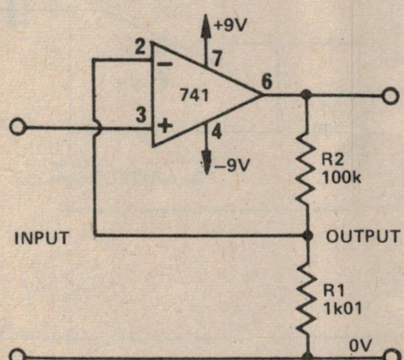

Fig. 10a Non-inverting x100 d.c. amplifier.

potentiometer and connecting the pot slider to the inverting terminal of the op-amp, as shown in the circuit of Fig. 10b. The gain of this circuit can be varied over the range x1 to x100 via R_1.

. . . AND RESISTANCE TO INPUTS

A major advantage of the non-inverting d.c. amplifier is that it has a very high input resistance. In theory, the input resistance is equal to the open-loop input resistance (typically 1M) multiplied by the open-loop voltage gain (typically 100 000) divided by the actual circuit voltage gain. In practice, input resistance values of hundreds of megohms can readily be obtained.

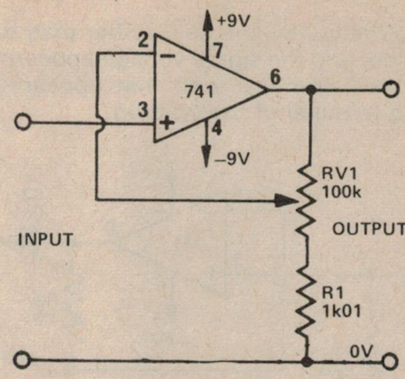

Fig. 10b Non-inverting variable gain (x1 to x100) d.c. amplifier.

BLOCKING OUT

The basic non-inverting d.c. circuit of Fig. 10 can be modified to operate as a.c. amplifiers in a variety of ways. The most obvious approach here is to simply wire blocking capacitors in series with the inputs and outputs, but in such cases the input terminal must be d.c. grounded via a suitable resistor, as shown by R_3 in the non-inverting x100 a.c. amplifier of Fig. 11a. If this resistor is not used the op-amp will have no d.c. stability, and its output will rapidly drift into saturation. Clearly, the input resistance of the Fig. 11a circuit is equal to R_3, and R_3 must have a relatively low value in the interest of d.c. stability. This circuit thus loses the non-inverting amplifier's basic advantage of high input resistance.

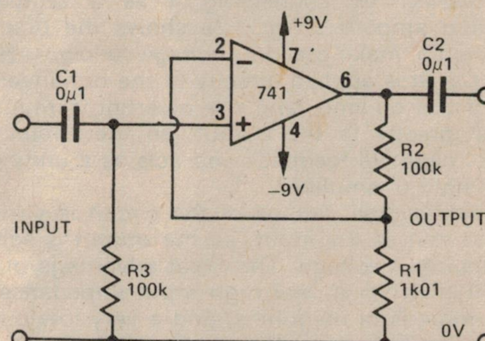

Fig. 11a Non-inverting, high input-impedance, x100 a.c. amplifier.

DRIFTING INTO STABILITY

A useful development of the Fig. 11a circuit is shown in Fig. 11b. Here, the values of R_1 and R_2 are increased and a blocking capacitor is interposed between them. At practical operating frequencies this capacitor has a negligible impedance, so the voltage gain is still determined by the ratios of the two resistors. Because of the inclusion of the blocking capacitor, however, the inverting terminal of the op-amp is subjected to virtually 100% d.c. negative feedback from the output terminal of the op-amp, and the circuit thus has excellent d.c. stability. The low end of R_3 is

connected to the C_3–R_1 junction, rather than directly to the ground line, and the signal voltage appearing at this point is virtually identical with that appearing at the non-inverting terminal of the op-amp.

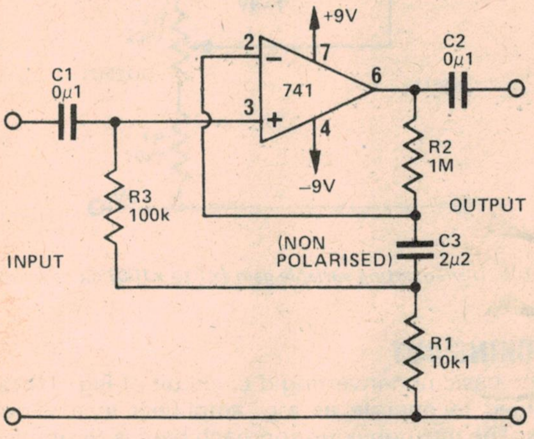

Fig. 11b Non-inverting x100 a.c. amplifier.

Consequently, identical signal voltages appear at both ends of R_3, and the apparent impedance of this resistor is increased close to infinity by bootstrap action.

This circuit thus has good d.c. stability and a very high input impedance. In practice, this circuit gives a typical input impedance of about 50M.

VOLTAGE FOLLOWER PROJECTS (Figs. 12 to 13).

A 741 can be made to function as a precision voltage follower by connecting it as a unity-gain non-inverting amplifier. Fig. 12a shows the practical connections for making a d.c. voltage follower. Here, the input signal is applied directly to the non-inverting terminal of the op-amp, and the inverting terminal is connected directly to the output, so the circuit has 100% d.c. negative feedback and acts as a unity-gain non-inverting d.c. amplifier.

The output signal voltage of the circuit is virtually identical to that of the input, so the output is said to 'follow' the input voltage. The great advantage of this circuit is that it has a very high input impedance (as high as hundreds of megohms) and a very low output impedance (as low as a few ohms). The circuit acts effectively as an impedance transformer.

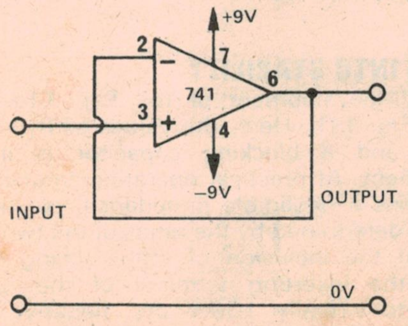

Fig. 12a d.c. voltage follower.

PRACTICE, AND ITS LIMITS

In practice the output of the basic Fig. 12a circuit will follow the input to within a couple of millivolts up to magnitudes within a volt or so of the supply line potentials. If required, the circuit can be made to follow to within a few microvolts by adding the offset null facility to the op-amp.

The d.c. voltage follower can be adapted for a.c. use by wiring blocking capacitors in series with its input and output terminals and by d.c.-coupling the non-inverting terminal of the op-amp to the zero volts line via a suitable resistor, as shown by R_1 in Fig. 12b. R_1 should have a value less than a couple of megohms, and restricts the available input impedance of the voltage follower.

LACED UP OHMS

If a very high input-impedance a.c. voltage follower is needed, the circuit of Fig. 12c can be used. Here, R_1 is boostrapped from the output of the op-amp, and its apparent impedance is greatly increased. This circuit has a typical impedance of hundreds of megohms.

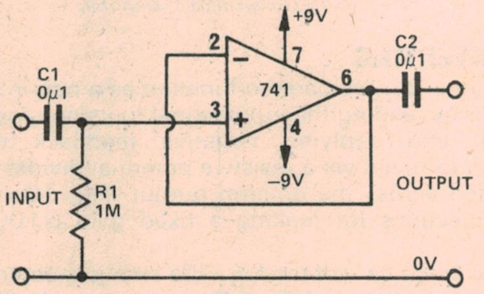

Fig. 12b a.c. voltage follower.

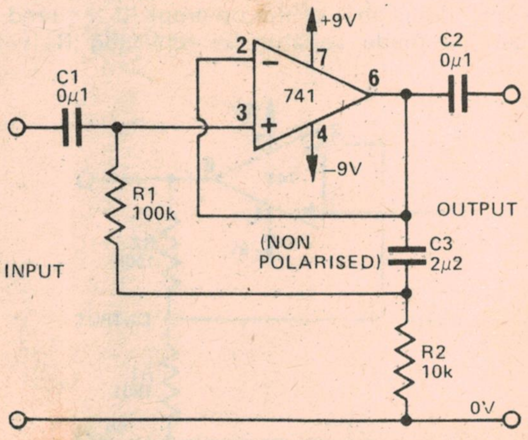

Fig. 12c Very high input-impedance a.c. voltage follower.

DRIVING CIRCUITS AMP-LY

The 741 op-amp is capable of providing output currents up to about 5mA, and this is consequently the current-driving limit of the three voltage follower circuits that we have looked at so far. The current-driving capabilities of the circuits can readily be increased by wiring simple or complementary emitter follower booster stages between the op-amp output terminals and the outputs of the actual circuits, as shown in Figs. 13a and 13b respectively.

Note in each case that the base-emitter junction(s) of

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Les Bell, ex-GM4CFM
Simon Bracken FX255

Advertising:

Sydney	Bob Taylor Geoff Petchler Tel 33-4282
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Publisher:

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This, the seventh issue of CB Australia, has been edited and produced by the staff of Electronics Today. It is presented free within the August 1977 issue of Electronics Today, and will also be available at the (recommended) price of sixty cents from all newsagents.

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A MODERN MAGAZINES PUBLICATION
15 Boundary Street, Rushcutters Bay, NSW 2011

CBers and radio amateurs recently got together for a seminar at Hillend (NSW). Discussions over three days ranged from radio procedure and regulations to operating and maintaining equipment. The organisers (the 4 Wheel Drive Radio Club of NSW) declared the weekend a success and plan to organise regular seminars.

We are glad to see that the Department of Posts and Telecommunications is cracking down heavily on pirates and CB'ers who violate the regulations. A particular case in point is that of a CB'er who was caught using an external linear amplifier, and who received a one month jail sentence.

Now, while we don't like the idea of people losing their liberty over what may seem to some to be a trivial matter, but even less do we like to think of a crowded CB band being dominated by these kind of people. CB is fundamentally egalitarian; men and women of all races, colours and creeds have an equal opportunity to converse — indeed, sociologists in America have already commented on the way CB is breaking down barriers and promoting 'inter-personal communication'.

Those who use linears are hogging the channel and denying its use to others, but worse still, they are triggering a vicious spiral which will end only when everyone has linears, but no-one can copy anyone else because of cross-modulation.

Let's nip linears in the bud.

FINAL FINAL

This is the last issue of CB Australia in its present format. CB is now legal (assuming you've acquired a licence!) and most of the hue and cry has died down — we feel we've accomplished most of our original aims. We've given you all you need to know about licensing and the technical problems involved in CB and we don't intend to start boring/insulting you with articles that don't tell you anything you didn't previously know. We've seen some of the magazines that follow that format and frankly it's not our style.

So from now on CB Australia will be published every *second* month — as a bigger and better version of our first issues. It will contain authorative articles on all aspects of CB radio, hard-hitting comparative reviews on CB rigs and associated gear, market run-downs on all the bits and pieces you need, plus full details of who makes and sells what.

The first issue of the new format CB Australia will be on sale in approximately two months time. You'll find it at all newsagents and it will be advertised in ETI and elsewhere. In the meantime a new CB Australia precis in Electronics Today International will keep you right up to date with what's happening. See you further down the log.

CONTENTS

CB NEWS

NEW TRUCKERS' CHANNEL

The old truckers channel, Ch.10 in the old US 23 channel system, on 27.085 MHz potentially (and actually) would interfere with the surf rescue frequency on 27.985 MHz as it was very close to the image frequency of the surf rescue channel receivers. As a consequence, the old channel 10 was not allocated in the Australian 18 channel system. This left the truckers with nowhere to go! By general agreement, the new truckers channel is channel 4 of the 18 channel Australian system, 27.055 MHz. This is the channel below the emergency calling channel and is channel 8 in the old US 23 channel system. So truck off to channel 4!

PRICE OF 27 MHZ RIGS TO RISE

Prior to legalisation 23 channel CB equipment was imported duty free under a customs by-law arrangement as 11-metre amateur equipment. Now, with legalisation, the entry of CB equipment into Australia will no longer be duty free and will attract the usual duty. This is likely to raise the price of 18 channel (modified 23 channel) SSB/AM rigs from around the $220 – $280 to $330 – $400! This makes UHF rigs quite attractive at a projected price of $300 with antenna included!

Most of the cheaper AM-only rigs available at the moment for less than $100 will most likely not meet regulation RB 249 which comes into force for all rigs licensed after 1st January 1978. So, if you buy a cheap AM rig now, you will likely only be able to use it until you renew your licence next year.

NOVICE AMATEURS TO GET CHEAP CB LICENCE

The P & T Department has indicated that novices may be able to obtain a CB licence by simply paying the difference between their amateur licence fee of $6 and the CB licence fee of $20 – only $14! The idea, it seems, is to compensate in some small way those novices who have an investment in 27 MHz gear to still get something out of their investment.

P & T TALKS TO CBER'S & AMATEURS

David Large of the P & T Department, the Department's resident 'CB expert', gave separate talks to NCRA and CB Club members and radio amateurs in Sydney in July.

Mr. Large gave a talk to the NCRA and Clubs in the first week of July on matters of concern to CBers, in a largely successful effort to clear up some of the rampant misconceptions and rumours that filled the channels following the introduction of CB. The meeting, particularly 'question time', was lively if anything and the audience was often aggressive and at times markedly hostile.

In contrast, the talk that Mr. Large gave to amateurs at the NSW WIA centre on the 22nd July was less 'provocative' but some searching questions were asked following his speech, the audience being for the most part less aggressive – and not easily provoked! Probably because most amateurs see themselves, and the amateur ranks, gaining from the introduction of CB.

Lots of interesting points came to light from the two talks and the respective questions – following are some highlights.

CLAMP-DOWN ON PIRATES

The Department is aiming to come down *heavy* on pirates operating adjacent to the allocated CB band – anyone found with/using a 40 channel rig is in big trouble – and those 'hard core' ex-CB pirates who move to other bands, like the 28 MHz and 21 MHz, etc., amateur bands. It has been noted that there are now Australian 'members' of the international radio pirates group 'HF International' operating locally – distinguished by their self-allocated call-sign prefix of 'HF'.

HARD LINE ON CB REGS.

The Department also aims to take a hard line on CB regulations violators. Recent case in point concerns a CBer caught operating a 'booster' (or linear). Among other penalties he copped a month in jail!

REPEATERS ON UHF!

If a CB emergency organisation emerges, as is likely, Mr. Large indicated that the Department would consider the establishment of repeaters for such a service. Repeaters would provide reliable range and coverage over great areas, greatly improving on emergency service. He said that the Department would be unlikely to consider UHF CB band repeaters under other circumstances as CB is intended as essentially a short-range communications service.

ONE MILLION LICENSEES BY 1982

The Department is projecting that there will be about one million CB licensees in Australia by 1982 – over 90% expected to be on UHF the year that 27 MHz gear will be no longer licensed for CB.

CB LICENCES DELAYED

An industrial dispute that commenced in NSW has held up the issuing of licences to CB applicants in all states. The dispute is essentially over staff arrangements within the P & T Department, the P.R.E.I. maintaining that there are insufficient staff to adequately process CB licences and that existing staff would be overloaded.

No licences will be issued during the currency of the dispute. However, licence applications will, no doubt, be received with alacrity! – so long as the appropriate $20 notes, money orders, cheques, etc. are attached!

Allan Grice, the well known Touring Car driver, has installed a Midland 13-892 SSB transceiver in his racing car transporter. The CB rig is mounted above the centre console and drives a pair of Twin Trucker top loaded antennas.

Questions and Answers on CB

I have a 23 channel AM rig and have only been on CB for about a month. The other day I put out a call on channel 8 and was told to go and find another channel by a station that called me back. I know that I'm not supposed to use channels 1, 2, 3, 4, 10, 21 and 23 — so why was I told to get off channel 8? What channels can I use?

Channel 8 on the old 23 channel system is the new Australian channel 4. This channel has been generally agreed upon for the use of truckers and those who want to talk to truckers. Truckers used channel 10 in the old 23 channel system before legislation and, as channel 10 is not allocated for use now in Australia (for technical reasons — it can cause interference to the Surf Rescue Service on 27.98 MHz), the new channel 4 was decided on as 'their' channel. It is not officially recognised as such, it is merely a 'gentlemen's agreement', and it is a courtesy not to use it for general CB use. The same applies to the emergency calling channel, Ch. 5 (old channel 9). In addition, channels 12 to 18 of the new system are for the use of SSB stations, channel 12 being the SSB calling channel (channels 16 to 22 of the old system).

Can a mobile rig be used as a base station?

Yes! Mobile rigs are designed to operate from a car battery which provides a voltage between about 12 and 14 volts. To use a mobile rig in a base station situation all that is required is a mains-operated power supply to provide a voltage around that of the battery. Commercially-made supplies are available and they generally provide an output voltage of 13.8 volts. Ensure that the supply can provide the necessary current — generally about 2 amps. DO NOT use a 'battery charger' supply as it is likely to damage the rig because its output voltage will be too high since the CB rig will not be a sufficient 'load' for it.

Which is the best rig to buy to reduce the possibility of TVI — an AM or an SSB rig?

Neither! — A UHF FM rig is really the best! If you want to use 27 MHz then an SSB rig is the better choice if you wish to reduce or avoid the possibility of television interference to nearby TV receivers. AM transmissions tend to 'block' or 'overload' the tuner of the TV set causing complete blanking of the picture in severe cases and generally a pattern of black lines when you speak. SSB, by its nature, does not have as severe an effect.

I have a Vector IX 23 channel AM rig which I installed a couple of weeks ago. Being new to the game and not knowing much about SWR or anything I cut two feet off the antenna coax which was 12 feet long. I have a 5 ft centre-loaded whip mounted on the left-hand cowl of my station wagon. When I measured the SWR it was over 5:1. I tuned the aerial as best I could and managed to get it down to 2.5:1. Not as good as I'd like but better than 5:1. Have I damaged my rig (it puts out three watts) and what could I do to get a better SWR reading? Does the length of the coax from the rig to the antenna make all that much difference?

The high SWR does not appear to have affected your rig any if you can still measure three watts output!

It seems that either the mounting is probably incorrect in some way or the connection from the outer braid of the coax to the car body is at fault. Check both of these. The outer braid of the antenna coax should be solidly bonded to the vehicle body at the base of the antenna; this is usually accomplished via the mounting supplied with the antenna. The metal surrounding the antenna mounting should be cleaned prior to installing the antenna mount so that good electrical contact is ensured. Also, before installing an antenna on the fender or cowl of a vehicle, plan its position so that it is no closer than 450 — 500 mm (18" — 20") from the nearest vehicle cabin pillar as this can affect not only the operation of the antenna but may also affect the SWR depending on the type of antenna.

The 12 ft length of coax often supplied with 27 MHz CB antennas is actually an electrical half-wavelength of feedline which has the property of repeating the actual antenna impedance at the end which connects to the transceiver. If the antenna does not quite provide a proper 50 ohm match which the transceiver expects, then, although the system is not matched, it doesn't matter very much (see our article on SWR). But if the coax is lengthened or shortened then the situation can become actually worse! Varying the length of the coax varies the actual impedance at the transmitter end. It is, in fact, possible to improve the SWR by lengthening or shortening the coax but it is a difficult method in CB applications.

If all else fails, you could always obtain a 'coupler' or 'matchbox'. We covered those in our CB Accessories survey back in Vol. 1, No. 3.

Can I use my existing car radio aerial for for CB?

To be brief, the answer is yes, but . . . it is not likely to be very efficient. If you aren't looking for maximum range and only use your CB rig for casual contacts at fairly short range, then it is often a good solution. Saves attracting the attention of 'rip-off' merchants too.

Firstly you will need a 'coupler' that will match the car radio aerial to the impedance required by your CB rig and provide a connection for your car radio to the antenna at the same time. These 'black boxes' are available commercially from a number of dealers — scan the advertisements or ask a local dealer. There are a couple of points to watch. Make sure that your car radio antenna is in reasonably good condition, the sliding joints should be cleaned with a degreaser — methylated spirits is quite good, so that good electrical contact is obtained between each section of the antenna, from the bottom to the tip. Clean it periodically. The antenna should be operated fully extended. Check the sliding joints periodically and clean them if necessary. Install the coupler strictly in accordance with the manufacturer's recommendations.

Why should UHF CB be better than 27 MHz? At such a high frequency, wouldn't it be worse?

Well, there are at least five reasons why UHF CB has the advantage over 27 MHz CB. Firstly, FM transmission provides higher quality communications, not high fidelity as is provided with FM broadcasting on the 88—108 MHz band, but clear, noise free (or largely so — except at extreme range) communications. No clarifiers, delta-tune or noise blanker controls are necessary! Then there is lower noise on UHF. The air is full of electromagnetic 'noise' generated by industrial machines, vehicle ignition systems — anything electrical that switches on and off, etc. It is a fact that this sort of noise has a peak in the radio spectrum around 25 — 30 MHz. It is also known that the level of this noise drops quite rapidly at frequencies above 50 MHz until at UHF the reduction in noise is some thousands of times less than at 27 MHz. This allows operation from much lower threshold signals areas — some areas would provide good signals on UHF and no communications on 27 MHz!

The range of UHF CB is largely the same as that experienced on 27 MHz, ignoring skip, which to many is just a nuisance! The range is generally much more predictable for UHF where it is not for 27 MHz.

UHF allows much greater use of channels owing to the characteristics of frequency modulation (FM) transmission. With UHF there is no 'carrier' to interfere with the carrier from another transmitter on the same channel as there is with AM transmissions on 27 MHz. Two AM transmissions on the same channel will cause 'heterodynes', the whistles you hear on the 27 MHz AM channels. With FM transmissions you get what is called the 'capture effect'. That is, the stronger signal on the channel will always prevail if two transmissions are on at the same time — you will only hear the stronger of the transmissions on the channel, and no heterodynes or interference.

With UHF transmissions there is almost a complete absence of TVI. UHF is well above the TV channel frequencies and no harmonics from a UHF CB rig can fall within the TV channels. TV sets also reject UHF signals much better than 27 MHz signals.

Apart from all the reasons given above, there are 40 channels available on the UHF CB band, the antennas can be mounted anywhere on a vehicle and will not require tuning!

HOW TO USE YOUR SWR METER

by Roger Harrison

Probably the most talked about topic on CB is *Ess Double-you Arr* and *SWRing* – and the most swearing goes on when the SWRing doesn't work out!

I briefly covered SWR in CB Australia No. 2. (March) and we had a look at SWR meters in No. 3. But, let's start at taws and briefly have a look at what *is* an SWR meter, what can it do for you and how to use one.

An SWR meter is a device used to indicate how good a 'match' you have between your transceiver, the feedline or transmission line and your antenna. The matching of these is important so as to ensure maximum transfer of power from your transmitter to your antenna and the most efficient transfer of a signal from the antenna to your receiver. But, one does not need to be a perfectionist as we shall soon see.

SWR is expressed as a ratio:– 3:1, 1.8:1 1:1 etc. The higher the ratio, the worse the SWR. 'One-to-one' is a perfect SWR, rarely obtainable and fortunately, not really necessary on CB. An SWR below 2:1 is quite acceptable and the table reproduce here should give you a good guide.

WHY SWR?

An antenna gives of its best when it is 'tuned' to the frequency on which it is to be used or to the centre of the frequency band over which it is to operate. For the 23 channel system, this is Ch. 12. CB antennas are made to provide the best match when tuned to the desired frequency and thus will have the least SWR when tuned. So, if you tune your antenna for the least SWR then you can be reasonably sure that it is operating correctly, all things being equal. We will assume for this exercise that you have mounted your antenna properly – see CB Australia No. 2.

CB antennas are generally supplied already tuned fairly closely to the band but mounting methods and nearby objects almost invariably alter the tuning slightly and it is necessary to at least *check* the SWR after installing an antenna. Those antennas that are supplied with some adjustment should be tuned to obtain the least SWR according to the manufacturer's recommendations.

The SWR of an installation should be checked at intervals to ensure that all is right.

A couple of SWR meters are illustrated in figure 1. As you can see, they may have one or two meters. Those having a single meter are fitted with a switch marked *'forward-reverse'* (often shortened to *'for-rev')* or perhaps *'forward-reflected'* (shortened to *for-ref'*). The dual meter types have one meter to measure 'forward' energy (power reflected from the antenna due to a 'mismatch'), to measure the standing wave ratio or SWR. Both types have a *'sensitivity'* control, the operation of which I will explain shortly.

CONNECTING THE SWR METER

Apart from the meter, you will need a 'patch' cable – a short length of coax

A typical SWR bridge.

HOW TO USE YOUR SWR METER

with PL-259 connections on each end. The SWR meter will have two coax sockets on it – the SO-239 type are standard – one marked *'transmitter'*, the other marked *'antenna'*.

Disconnect the feedline from the transceiver socket and plug it into the *antenna* socket of the SWR meter.

Then, taking the short 'patch' cable, connect the transceiver antenna socket to the *'transmitter'* socket on the SWR meter. The basic set-up is illustrated in figure 2.

Some SWR meters have small switches, usually located on the back, marked '50' and '75' or something similar. These should normally be switched to '50' as they set the instrument to correctly measure the SWR in a '50 ohm' system which is used for CB installations (the transmission line or coax, the transceiver and the antenna are all meant to match an impedance of 50 ohms – see CB Australia No. 2.) SWR meters that do not incorporate these switches are generally made for use with 50 ohm systems.

An SWR meter can be left permanently installed if desired, or convenient, so that the performance of the transmitter and antenna system can be constantly monitored. In other words – peaco of mind, if you're that way inclined !

MEASURING THE SWR

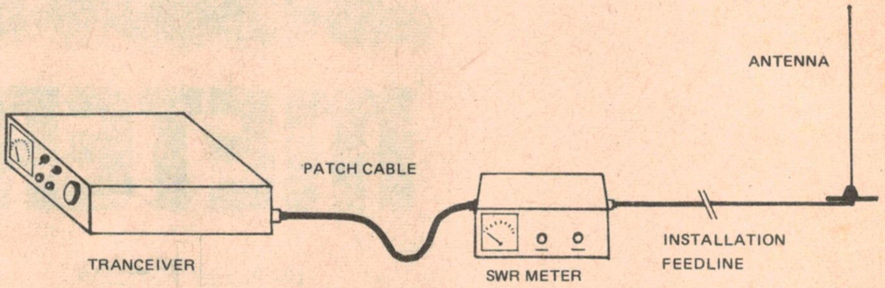
The transceiver should be set to the frequency you will, or do, use the most or channel 12 (27.105MHz) which is the centre of the 23 channel system. SWR measurements or checks should be carried out with the transceiver in the AM mode to provide a sustained RF power output. A sustained whistle can be used on SSB if you wish – but you might run out of breath before you can tune your antenna !

Keep measurement periods short to avoid interference with others; make sure the channel is clear before commencing in any case. Or you could SWR your antenna at three o'clock in the morning !

Follow the step-by-step procedure here and you will be surprised how easy it is !

(1) If you are using a single-meter instrument, switch to read *'forward'*.

Figure 2. Set-up for measuring SWR.



(2) Turn the *'sensitivity'* control to minimum and then press the transmit button. Quickly adjust the sensitivity control to obtain maximum reading on the meter, or the forward meter on instruments with two meters.

(3) Now switch to *'reverse'* or *'reflected'* and the SWR will be indicated on the meter scale. Two meter instruments will show SWR on the 'reflected' meter.

(4) The table reproduced elsewhere will tell you whether to worry or not !

Some SWR meters incorporate a power measurement scale or a separate meter for measuring power. The function switch in these models usually has three positions: *power, forward* and *reverse* (or *reflected*). The SWR measurement should be made as for a single meter instrument, as explained above.

ANTENNA TUNING

If your antenna needs to be tuned then the procedure is a little different. The set-up remains the same and you should carry out an initial check of the SWR as outlined above. Now, make a small adjustment to the antenna as detailed by the manufacturer. Switch the SWR meter to read *forward* and adjust the *sensitivity* control to give maximum reading again if necessary. Now switch to *reflected* (or *reverse)* and read the SWR. If it has decreased (from say over 2 down to 1.8 for example) your adjustment was in the right direction. Make a further adjustment in the same direction, switch the SWR meter to read *forward* again and repeat the procedure.

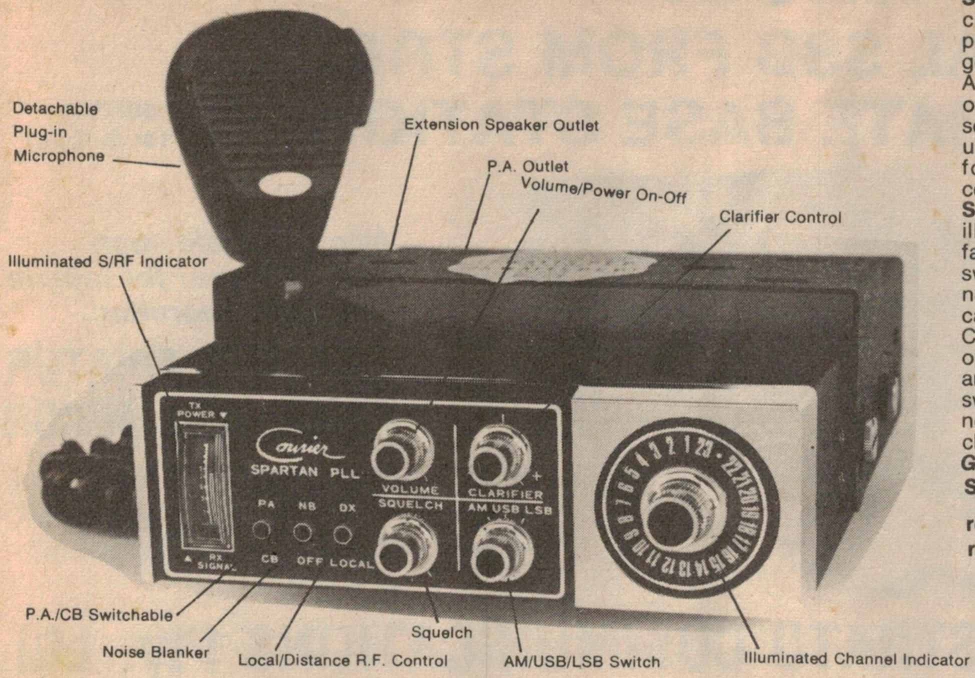
If, on the other hand, the SWR reading increased after you adjusted the antenna, then your adjustment was in the wrong direction. Make an adjustment in the opposite direction, set the SWR meter to read *forward* and repeat the procedure.

Once the SWR reading does not change very much with an adjustment, or you have reached an SWR of 1.5, it is wise not to continue because, for a start, it is a little pointless – as explained in the table, and if the adjustment to the antenna is by means of 'pruning' the tip by cutting off short lengths, then you may possibly go too far !

If you are using an 'antenna coupler' or 'matcher' then the procedure is much the same. After each adjustment of the coupler or matcher, reset the *sensitivity* control of the SWR meter for maximum *forward* reading and then switch to reflected or reverse to read the SWR. If the SWR goes down, you're adjusting the coupler or matcher in the right direction, if it goes up, you're adjusting it in the wrong direction.

As a last note, the power measurement facility on many SWR meters is very handy, but an accurate reading can only be obtained if the SWR is fairly low (say, 1.5:1 or less). If you want to check your power output properly, obtain one of the inexpensive CB 'dummy loads' and plug it into the *'antenna'* socket of the SWR meter in place of the feedline to the antenna. The meter should be set to read power and when you press the mike button (with the transceiver set to the AM mode), you can read the power output of your transmitter.

SPARTAN PLL SSB



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Get everything you want in SSB with Spartan PLL.

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SPECIFICATIONS

General
- o Phase Locked Loop Digital Synthesizer
- o Dimensions: 7-1/2" x 2-5/16" x 9-1/2"
- o Weight: 6 pounds
- o Transistors: 31
- o Diodes: 47
- o Integrated Circuits: 6
- o Thermistor: 1
- o FET: 6
- o Lattice crystal filter for SSB
- o Mechanical ceramic filter for AM
- o SSB Noise Blanker: FET series gate type
- o Pos/Neg. ground

Transmitter: SSB Section
- o Input Power: 25 watts PEP at 13.8 VDC
- o Output Power: 12 watts PEP at 13.8 VDC
- o Spurious Harmonic Suppression: —50 dB
- o Carrier Suppression: -40 dB
- o Unwanted Sidebands: -45 dB
- o SSB Filter: 7.8 MHz crystal lattice type 6 dB at 2.1 kHz, 60 dB at 5.5 kHz
- o Output Impedance: 50 ohms
- o Frequency Stability: ±.003 percent at -20 C to +60 C

Receiver: AM Section
- o Sensitivity: 0.4 v for 10 dB S+N/N
- o Selectivity: ±3.5 kHz at 6 dB
- o Adjacent Channel Rejection: 60dB at 10kHz. 60dB at 20kHz.
- o Squelch Sensitivity: 0.4 v

Receiver: SSB Section
- o Sensitivity: 0.15 v for 10 dB S/N
- o Selectivity: ±2.1 kHz at 6 dB
- o Adjacent Channel Rejection: 70dB at 10kHz. 70dB at 20kHz.
- o Squelch Sensitivity: 0.3 v

Both AM & SSB Sections
- o Clarifier: ±800 Hz (Receive only)
- o Noise Blanker: Series gate type (AM), FET (SSB)
- o Audio Output: 5 watts: 450 Hz to 2500 Hz ± 6 dB

Transmitter: AM Section
- o Output Power: 3 to 4 watts at 13.8 VDC
- o Modulation Capacity: 100 percent
- o Spurious Harmonic Suppression: 50 dB
- o Output Impedance: 50 ohms
- o Frequency Stability: ± .003 percent

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HOW TO OPERATE

by Roger Harrison

For old hands and newcomers alike, a little 'operating technique' goes a long way to making an enjoyable contact or QSO (in the jargon).

Well, your 'rig' has just been installed, you sort of think you know what all the knobs do and you know how to press that little button on the mike! And then it suddenly strikes you . . . "Ohmigawd, what the *@&$% am I going to say! How do I call somebody – anybody!"

"Maybe I'll just listen for a bit and see what the others do".

That makes pretty good sense really, except that how the hell do you interpret '10–4 on that 10–32, let's 10–27 to 14 and see if it's a 10–2', and what is QRM and QRN and a QTH and why would anybody want to QSY? How do you give callsigns properly and signal reports, how do you break in on a contact, how do you ask *anybody* for a contact?

Know Your Rig First

If you're new to CB, it is best that you get to know your rig first; what all the controls are, what they are for and what happens when you adjust them; how to get the best reception under various conditions etc. Most rigs have a handbook which basically explains the controls and something about their function. Back in CB AUSTRALIA No. 1 (February 1977), we had an article on 'Understanding CB gear' which explained the various controls found on CB rigs, their function and how to use them (as well as how *not* to use them).

Getting to know your rig pays dividends very quickly; a little practice goes like Peck's paste – a long way. Have a general listen around the channels for a day or so. Get to know which are the popular channels and who operates on them. In doing so you will rapidly learn how to operate your receiver and not make so many boo-boo's to begin with. You will also pick up a little of how to operate, what to talk about etc., from listening to the contacts other people have. Just to save you picking up the mistakes and bad habits of others though, the rest of this article spells out how to go about having, and enjoying, conversations on CB radio.

Channel Usage

By general agreement, or is that gentle-person's agreement, and largely by practice, the eighteen channels are divided into different 'uses', a practice largely adopted from the old US 23 channel system. There are general 'calling' channels for both AM and SSB transceiver users. One channel for AM-only users and one channel for SSB-only users. Calling channels are intended to be used only to establish a contact, not for conducting a conversation. That is, you establish contact with a particular station, or whoever answers your general call ('CQ' – explained later), and then both of you move to some other clear channel to conduct your conversation.

The general channel usage and the calling channels are listed in the separate box. Note that channels 1 to 11 are generally for AM working and channels 12 to 18 for SSB.

Note that there is an 'emergency channel', channel 5 (27.065 MHz). This channel, although not officially recognised as such, is used for emergency communications to report situations that may require assistance of some sort from one or more of the public authorities (police, fire brigade etc), such as road accidents, fires etc. AM or SSB can be used to call on this channel. This channel is widely monitored by stations who are members of CREST, the Citizen's Radio Emergency Service Team. It is courtesy not to use it for conducting contacts or as an alternative calling channel.

We'll talk later in the article about how to use this channel when necessary.

Calling 'CQ'

To commence a contact, or QSO as it is often called (see Q-code later), if you are not calling a specific station, you put out a CQ call. This indicates to all stations that may be listening, and can hear you, that you are after a contact with anyone who cares to answer your call.

To put out a CQ call, first listen on the appropriate calling channel, Ch. 6. if you are operating AM, or Ch.12. if you are operating SSB. If the channel is

27MHz CHANNELS

Aust. Ch. No.	Equiv. US Ch. No.	Frequency	Usage
1	5	27.015 MHz	AM
2	6	27.025 MHz	AM
3	7	27.035 MHz	AM
4	8	27.055 MHz	AM
5	9	27.065 MHz	AM or SSB Emergency Calling
6	11	27.085 MHz	AM General Calling
7	–	27.095 MHz	AM
8	12	27.105 MHz	AM
9	13	27.115 MHz	AM
10	14	27.125 MHz	AM
11	15	27.135 MHz	AM
12	16	27.115 MHz	SSB General Calling
13	17	27.165 MHz	SSB
14	18	27.175 MHz	SSB
15	19	27.185 MHz	SSB
16	–	27.195 MHz	SSB
17	20	27.205 MHz	SSB
18	22	27.225 MHz	SSB

This 23-channel set by Realistic (the Tandy brand name) has the minimum of controls for easy operation.

not clear then wait until it is clear or find a clear channel and then proceed.

Having got a clear channel, put out your call something like this:—

"CQ, CQ channel 12 (or whatever channel you're on), this is NBC 123 calling CQ and standing by"

or

"Calling CQ, CQ, this is NBC 123 calling CQ channel 12 (or whatever) and listening"

When calling CQ it is a good practice to announce the channel number along with your callsign so that a station wishing to reply can indicate that he is calling you, and for those with 'scanning' receivers (which switch automatically across a number of channels, briefly indicating calls or contacts on the channels) know which channel to call you on.

Speak at a reasonable pace, not fast so that your words are blurred, nor slow so that the call is dragged out. Having made the CQ call, release the mike button and listen for the replies! What happens if you get no replies? Have another try or several with short listening intervals in between. You may need to try another channel.

A short call is generally the most effective. If someone's on channel they will answer you or ask for a repeat. They may ask 'QRZ?', which is the Q-code call for 'what station is calling' — in other words they are asking you to repeat your callsign.

Calling CQ over and over unnessarily ties up a channel and is not likely to win you friends, let alone 'good buddies' (if you want them that is!).

Always listen on the channel first and *only* use a general CQ when you are willing to work any station who answers.

If you want to work stations in a particular location or area then a 'directional CQ' is best used. Simply modify the calling procedure, something like this:—

"Calling CQ North Sydney mobiles, calling CQ North Sydney mobiles, this is NBA 123 looking for a Bridge traffic report, NBA 123 standing by."

or

"Calling CQ Box hill, CQ Box Hill, this is VBB 456 calling CQ Box Hill, VBB 456 standing by."

Make sure that the area you are calling is within range otherwise you will be unnecessarily tying up a channel and possibly causing interference.

When replying to selective CQ calls, only do so if you are in the area named, otherwise you may not get a reply (if the operator is polite), or a few curt words (if the operator is feeling less than polite).

In well populated areas, or where activity is high, the CQ call may actually be dispensed with and you can simply announce that you are on channel. Like so:—

"NBA 123 on channel, NBA 123 by".

That sort of call is short and should result in a reply if anyone's on channel. If that doesn't work, then give one or more general CQ calls.

Replying

Wonderful! Somebody answers your call! They might reply something like this:—

"NBC 123 this is NBA 422, I copy you 5 by 9, the handle here is Gus, NBC 123, NBA 422 standing by".

or

"Hello NBC 123, this is NBA 011, fine copy good buddy, 10–2 at this 10–20, what's my QSA, handle's Bob, whadderyasay. Go?"

Now, that last one's 'slinging the lingo' a bit heavy and, unless you've memorised all the codes, it doesn't mean much to you, does it? What's more, it looks a bit ridiculous in print doesn't it? It sounds just as bad or worse on the air. Anyway, at this stage who's whose 'good buddy'? If you don't understand what somebody says to you, especially if they use the 10-code or the Q-code, ask them to repeat it in plain English! If they're offended, that's their problem. The idea is to communicate with people, not confuse them.

The first reply example above is much easier to understand. The '5 by 9' is a signal reporting system which will be explained shortly. Until you are used to the system, and used to operating your transceiver, just report how the other station sounds in simple terms. If the signal is loud and clear with no interference or noise then say that. If the signal is fading a little and is not too strong, but you can hear, or 'copy', the station quite adequately . . . then say so, in exactly those terms. If you are experiencing difficulty, perhaps owing to some noise or interference etc, then say so and the other operator can repeat his comments or talk more slowly so that you can copy him somewhat better. Do the same for the other operator if he is experiencing similar difficulties.

Acknowledgements

When replying to a call or comments in the other station's over, it is both a courtesy and good practice to acknowledge the call or comments. The commonly used word acknowledging a

THE SIGNAL REPORT CODE

Readability

1	Signal unreadable
2	Barely readable, occasional words distinguishable
3	Readable with considerable difficulty
4	Readable with practically no difficulty
5	Perfectly readable signal

Signal Strength

1	Faint signals, barely perceptible in noise
2	Very weak signals, down in the noise
3	Weak signals, quite noisy
4	Fair signals, noise in background
5	Fairly good signals, some noise in background
6	Good signals, not much noise in background
7	Moderately strong signal, little noise in background
8	Strong signal, almost noise free
9	Extremely strong signal, noise free

comment or message is "Roger", or sometimes "Romeo".

It goes like this:—

"NBA 456 (other station's callsign), this is NBA 123 (your callsign). Roger on those details, etc etc."

or

"Roger NBA 456, NBA 123 replying, etc etc . . .".

Signal Reports

One of the first things to tell the other operator when you establish contact is a signal report of how you receive, or copy, his signal. This is done generally by means of a 'Readability' and 'Signal Strength' code. The readability of a signal is graded in steps from 1 to 5, from unreadable to perfectly readable — that is to say, how well the transmission can be understood under the conditions. The signal strength is graded in steps from 1 to 9, from barely perceptible to extremely strong — many transceivers include a signal strength meter or 'S-meter', although they should never be regarded as accurate, merely an 'indication'. It is unlikely that any two S-meters will read the same under identical conditions. Don't worry about it though. No matter how weak the signal, if you can understand the operator — that is to say, if the signal is good copy, then that's all that's necessary.

The signal report code is given in the accompanying box.

Conducting a Contact

Now you know how to call CQ and how to give a signal report, you can get stuck into the 'meat' of a real contact.

You've called CQ and a station has replied and perhaps given you a signal report and his name or 'handle'. You can then reply in similar fashion to start the contact, or QSO.

The period for which each operator speaks is called an 'over'; so let's see how the first few overs of a contact may go:—

"CQ, CQ, this is NBA 123 calling CQ channel 6, NBA 123 standing by".

"NBC 123 this is NBC 011, you're 5 by 9 and the handle here is Jack. How do you copy, over".

"NBC 011 this is NBA 123, your signal is loud and clear and my name is Terry, over".

"NBA 123, NBC 011. Good copy Terry. The rig here is a Tram and I'm running a helical on a roof rack. I'm heading down the coast a bit for the weekend, I hope the weather holds out. What are you up to yourself. Over."

"NBC 011, NBA 123. OK Jack. The rig here is a Gemtronics and I'm using a top-loaded whip mounted on the boot lip. I'm on my way to Carparts in Highfield for some hub caps at the moment. Are you going fishing or surfing down the coast Jack? Over."

And so on . . .

When replying to the other station, *always* give his callsign first. That's in section 6.3 of RB14 if you want it in chapter and verse!

Leave several seconds pause between overs to allow other stations to break in if they wish. Keep overs short, don't ramble — you may be boring more than just the operator you're talking to!

What to talk about. That *should* be pretty simple. Anything really (except what is expressly forbidden in the regulations). Discuss your rigs, ask about any information you need (road conditions, directions, practical info., local club meetings etc.) arrange an 'eyeball' — have a conversation!

However, always remember the **cardinal golden rule:—**

ENSURE BRAIN IS ENGAGED BEFORE PUTTING MOUTH IN GEAR

. . . then press the mike button.

When ending a contact, observe the common courtesies, but don't take it too far. A commonly used expression is "73's", which means 'best wishes'. Another one that should not be so commonly used is "88's" which means 'love and kisses'. Some 'slick' (or is that sick?) operators expand that to "all those big numbers to you".

Now, unless you happen to be a raging queen, that sort of exchange between members of the same (or even similar!) sex is pointless and ridicules the operator who uses the expression. It sounds contemptuous when applied to a member of the opposite sex.

In short, lay off the slang.

I may be casting pearls before swine or dribbling into the ocean but bad operating practices help nobody.

Calling a Specific Station

If you have a friend or acquaintance with a CB license, and you know his callsign; or if you wish to reply to a station calling CQ, then the procedure is as follows:—

"NBC 456 (other station's callsign), this is NBB 012 (your callsign) calling. How do you copy? Over."

And from there you can proceed with the contact as explained previously.

'Breaking' a Contact

When joining a contact already in progress you announce your presence between the 'overs' of the other stations, as follows:—

"Breaker NBC 123 (your callsign)"

or

"Breaker Channel 12 (or whatever channel you're on)"

But it is better practice to announce your callsign. You can also announce your presence simply by announcing your callsign between overs of the stations you wish to break in on.

Now, the stations you are 'breaking' may call you in like this:—

"Go ahead the breaker".

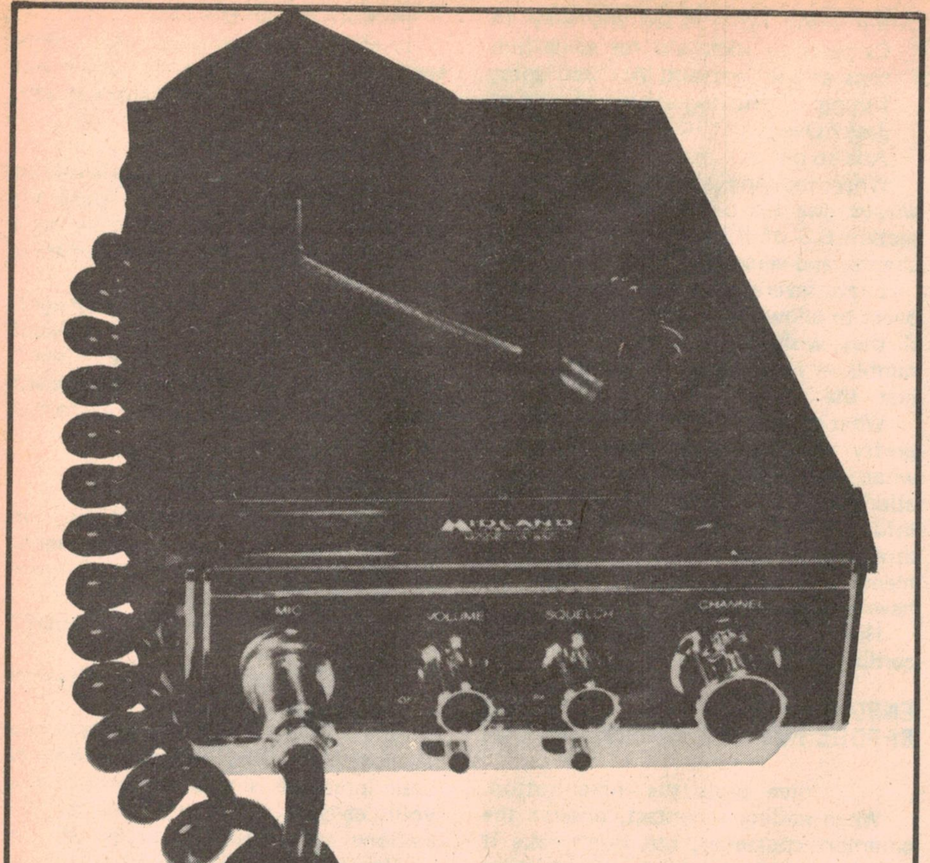
or

"Go ahead NBC 123 (your callsign as you are 'breaking'), this is NBB 012 and NBB 456 standing by."

You then proceed by announcing both their callsigns, or the last callsign spoken if there are a group of stations in a 'net', followed by your callsign and whatever you want to say.

"NBB 456 and NBB 012, this is NBC 123, I have some details on what you are discussing etc etc etc".

A delta-tuning control and noise blanker can greatly improve reception.



This Midland CB is ideal for under-dash mounting.

Sometimes the stations you break may ask you to stand by:—

"Breaker stand by please".

or

"QRX the breaker" (QRX is Q-code for 'stand by')

If another station breaks your contact and you ask him to stand by it is courtesy to call him in on the *next* over so as not to keep him waiting too long; he may have emergency traffic!

If a station breaks your contact and you miss his callsign or don't understand it then you can say:—

"Come again the breaker."

or

"QRZ the breaker" (QRZ is Q-code for 'what is your callsign?')

It is bad practice, even dangerous, to break a contact where emergency traffic is being passed; *UNLESS* you can materially assist.

Codes

Various codes are used on the air as a sort of shorthand — but you can take it too far. Intelligent use of the codes can convey messages and meanings concisely and with accuracy.

The 'Q-code' is largely used by radio amateurs and has been adopted by CBers both in the US and in Australia. It is quite old in origin, arising from morse telegraphy operation before radio transmission by voice became possible. and it has carried over as it does convey a certain meaning concisely and accurately. The code is fairly simple and can be used either to ask a question or give an answer, or to make a request.

The commonly used Q-codes are listed here:—

QRA	**What is your name or handle? My name is . . .**
QRM	**Does my signal suffer from interference? Your signal suffers from interference.**
QRN	**Does noise (static, ignition noise) affect my signal? Your signal suffers from noise interference.**
QRT	**I will stop transmitting. Will you stop transmitting?**
QRU	**I have nothing for you. Have you anything for me?**
QRV	**I am ready. Are you ready?**
QRX	**I will stand by. Will you please stand by?**
WRZ	**Who is that calling?**
QSA	**What is my signal report? Your signal report is . . .**
QSB	**Is my signal fading? Your signal is fading.**
QSL	**I acknowledge receipt. Do you acknowledge receipt?**
QSO	**Contact or communications.**
QSY	**I am changing frequency (or channel) to . . . Will you change frequency (or channel) to . . .?**
QTH	**Location or address.**

Don't bother about learning it off by heart if you are just starting out in CB, you will pick it up as you go along — surprisingly quickly!

The '10-code' is used by the US police and is an imported 'legend'. If slinging the lingo and feeling superior by confusing people with codes is your bag then the 10-code is tailor-made for you.

All that notwithstanding (heretofor and hereafter, as they say in the classics), the 10-code is in use and probably has as much place as the Q-code. It is certainly more detailed. The commonly used 10-codes are listed for easy reference below:—

10–1	**Receiving poorly**
10–2	**Receiving well**
10–3	**Stop transmitting**
10–4	**OK, message received**
10–7	**Out of service, leaving air, not working**
10–8	**In service, subject to call, working well**
10–9	**Repeat message**
10–10	**Transmission completed, standing by**
10–13	**Advise weather/road conditions**
10–20	**Location (thus 'Home 10–20' or 'Home – 20' is home address)**
10–23	**Stand by**
10–27	**I am moving to channel . . .**
10–28	**Identify your station, what is your callsign**
10–32	**I will give you a radio check. Will you give me a radio check?**
10–33	**EMERGENCY TRAFFIC AT THIS STATION**
10–34	**TROUBLE AT THIS STATION, HELP NEEDED**
10–41	**Please tune to channel**
10–44	**I have a message for you (or for . . .)**
10–50	**Break channel**
10–77	**Negative contact**

When passing information under difficult conditions, or in order to clarify the spelling of a word, the Phonetic Alphabet is used. The phonetic alphabet given here is one in fairly common use (there are several) and its use results in little or no ambiguity when passing information, particularly in emergency situations. Memorising it is a good idea . . . but don't practise on the air!

If on some occasions you cannot remember the appropriate phonetics, use your common sense but make sure that a message has been received correctly.

THE PHONETIC ALPHABET

Letter	Spoken as	Letter	Spoken as
A	ALFA	N	NOVEMBER
B	BRAVO	O	OSCAR
C	CHARLIE	P	PAPA
D	DELTA	Q	QUEBEC
E	ECHO	R	ROMEO
F	FOXTROT	S	SIERRA
G	GOLF	T	TANGO
H	HOTEL	U	UNIFORM
I	INDIA	V	VICTOR
J	JULIET	W	WHISKY
K	KILO	X	X–RAY
L	LIMA	Y	YANKEE
M	MIKE	Z	ZULU

Using the Emergency Channel

When you wish to use the emergency channel to pass information or to call for assistance give a short call and state that either you have a message to pass or are calling for assistance. Give your callsign at the beginning and end of your call.

Always be brief and to the point. Give *relevant* details, not graphic descriptions. Answer any requests immediately, so far as is possible.

Don't break an existing contact on the emergency channel unless you have urgent traffic or request for assistance.

Don't call CQ on the emergency channel or use it as a calling channel. Don't conduct everyday QSO's on the emergency channel.

Points to Remember

* Speak clearly at all times; using rhythm, at a speed that is generally not too fast — perhaps a little slower than you normally do, or faster if you're a slow talker! Try and maintain a nearly constant volume; don't let your sentences dribble off at the end.
* Use plain language mostly. Use the codes only where they seem called for or to make a message or meaning unambiguous. Long strings of the codes only confuse people — even though it might sound pretty smart.
* Remember the courtesies — it's good practise and helps everybody enjoy a contact.
* Forget about 'all them big numbers' — it's kid stuff!
* Keep overs short, precise and to the point. Leave a short pause between overs for breakers.
* Keep CQ calls short, repeat at intervals if you get no reply.

Keeping a Log

A 'log' is a chronological list of the stations you have contacted and relevant details of each contact. It is not necessary to keep a log; it isn't mentioned in RB14 (the regulations), however some stations keep a log for their own interest and to send confirmations of contacts in the form of 'QSL' cards — a sort of post card giving details of the contact you enjoyed with a particular operator. Exchanging QSL cards has been a long-standing tradition of amateur radio operators and has been taken up by CBers as well. Many clubs can sell you QSL cards which you can use or you can have your own printed. QSLing is really the subject of another article.

Commercially printed log books are available and certainly obviate the necessity of drawing up your own. However, if you want to draw up your own, all you need is an exercise book or loose-leaf ring binder and you can rule up columns under the following headings:—

DATE/TIME STATION WORKED HIS S-REPORT (to you) YOUR S-REPORT (to him/her) CHANNEL REMARKS (NAME).

They are the basic columns under which to record details of your contacts. You could add an extra column on the extreme right in which to record the name of the operator of the station worked. It makes for quick reference on later occasions.

DON'T FORGET . . at all times **ENSURE BRAIN IS ENGAGED BEFORE PUTTING MOUTH IN GEAR** . . . it'll save you a lot of embarrassment!

Many CB'ers are taking up amateur radio and going for their novice licenses — this novice transmitter for the 80m band was described in Electronics Todav. May 1976: back issues are available for $1 each.

'Half a watt is better than no watt' CB in NEW ZEALAND

By **JOHN GAINES**

While Australian CBers celebrate their newly-won legal status, over the Tasman it's business as usual in the field of personal communication. However, New Zealand is proof that early legality need not give rise to an ideal system.

IN NEW ZEALAND tens of thousands of CB sets are in daily, and quite legal, use. But not on the frequencies at the lower end of 27 MHz. Citizen's Band has been allocated 26.5 MHz because 27 MHz is an industrial, scientific and medical band used for diathermies, industrial welders, and telemetry

The original frequency allocated was 465 MHz, back in the 1950s, but there were no sets available for this frequency, no interest and no licences were ever issued.

On 24 March 1961 the Director-General of the New Zealand Post Office issued a statement that it had been decided to allocate the additional frequency of 26.5 MHz for use in the Citizen Radio Service.

Sets had to be type approved by the Post Office and this is now a detailed specification, RTA23.

In August 1963 additional frequencies were allocated, 26.425, 26.450, 26.475, 26.525, 26.550, and 26.575 MHz. The complaint now is there aren't enough frequencies as compared with the American's 23, and now 40, and that the New Zealand Government created the 7 channels and then in biblical fashion rested.

The first set approved for use was the Heathkit GW10 on 16 October 1961, conditional on the whip aerial not exceeding 10 feet. There are now 121 different brands and types of set approved. Foreign brands abound but usually the power has to be cut and facilities such as tone calling disabled.

Most sets in use are locally manufactured, though possession of an American set has prestige, especially if it is over-powered. Piracy is rife. After all, it's probably more fun to operate without a licence, using a fictitious callsign, with a set running 5 watts instead of the permitted half watt, in the delicious anticipation that a Radio Inspector or Roger India will suddenly knock at the door with all the weight of the Radio Regulations behind him.

To be legal costs six dollars a year for the licence. You have to be British, which in New Zealand is officialese for being a New Zealand citizen.

A callsign is allocated to each set licensed. There is a two-letter district prefix, such as AK, the abbreviation for Auckland, followed by a number which runs from 1 for the first set licensed up into the thousands now. The full callsign, with the district prefix and number, must be used at all times. The callsign has to be announced at the commencement and the end of each transmission and at least every 5 minutes during lengthy transmissions. Calls must be directed only to specific stations in the citizens Service. General calls to all stations, (ie CQ calls) are not to be made except in emergencies.

Communication with stations outside New Zealand is not permitted, the sets being licensed only for contact between similar stations in New Zealand. The transmission of news, music or other entertainment or recordings of any kind on citizen channels is prohibited. That's quite a list of no-noes, but many official rules are ignored.

Technical limitations

The maximum power is 0.5 watt. This is considered to be adequate to satisfy the short range communications requirement for which the service is intended. In addition, it permits a high degree of channel sharing with a minimum of interference between stations.

But for type approval, which costs twenty dollars, there are other conditions to be met. Some of them are:

Antenna The antenna shall preferably be an integral part of the equipment and may be either a monopole (with or without ground plane?) not exceeding 3 metres in length or a centre-fed dipole not exceeding 6 metres in length. The antenna may be separately mounted and fed by a non-radiating type of transmission line.

The radiating element may be helically wound, inductively loaded or folded to permit easier matching to the transmitter or transmission line but antennas employing parasitic elements to give greater gain than the above-mentioned types are not permitted.

Vertical polarisation must be used in all cases.

Environment The equipment shall meet the requirements of frequency tolerance, unwanted emissions and power output when tested over the range of temperatures between 5 degrees Centigrade and 30 degrees Centigrade with the following supply voltage variations:

(a) Mains operated equipment:— ± 10%

CB in NEW ZEALAND

(b) Lead-acid battery operated equipment:— 1.8V to 2.3V per cell.

(c) Other power sources:— Maximum possible operating voltage down to the voltage at which the equipment fails to operate.

Frequency Tolerance ± 0.005% of the nominal frequency.

Unwanted Emissions With no modulation or when a loud talker speaks into the microphone the peak level of any discrete components in the rf output spectrum outside of either 10 kHz below or 10 kHz above the carrier frequency shall not exceed —40 dB relative to the carrier power except that components which are harmonics of the carrier frequency shall not exceed —30 dB relative to the carrier power.

Power Output The rf power output when the transmitter is modulated with a sinusoidal tone to the maximum depth obtainable shall not exceed 500 mW.

But when the overseas traveller fronts up to the Radio Inspector's office counter with a pair of CB sets he's bought cheap in Suva he's often in trouble. The Indian duty-free dealer didn't tell him he needed a licence or type approval, small matter to him.

Often they can't be licensed. For the twenty dollars the Post Office will look at them for type approval, but they perhaps won't comply, unwanted emissions being where the cheaper sets often fall down.

Licensees are not allowed to modify their equipment in any way. The replacement of transistors by types no longer available, or which might have given trouble in some brands (as has happened) is not looked at with favour. It's possible to put switches in for multi-channel use on single or dual-channel early-model sets — but it still has to be looked over by the local Radio Inspector.

NZ sets and Prices

Local sets are Airlane, Autocrat, Telstat, Tait. Typical of current prices is the Tait CB4. The basic unit is $192, mains power unit $45.28, portable kit with helical whip $21.20, mobile cradle $11.04, mobile speaker $12, gutter grip helical antenna $21.54, roof mount helical antenna $25.54; crystals per pair $7.60, ground plane antenna for base station $52.92.

Every Radio Inspector's Office in NZ, all 17 of them, has a safe full of CB sets that have been taken into custody, for illegal operations, illegally modified for high power or illegally modified for use on 27 MHz.

The sunspot cycle is at a low point, and skip is not very prevalent; but now we're into the upswing and as the higher frequencies open up skip will become more common and it's a temptation for New Zealanders when 26 MHz CBers can be heard to buy 27 MHz crystals — any bicycle shop can provide them.

Bike shops often sell CB sets, maybe because bicycles haven't been good business. A simple solder job, a retune and there we are talking to Australia and it doesn't cost a dollar fifty a minute which the NZPO asks for the use of its telephone system. This is Buck Rogers stuff, now. And after all the radio spectrum belongs to the people of the world, not a monolithic government department!

And to hell with the International Telecommunications Union which lays down the world-wide rules for communications. We aren't doing any harm. And when a CBer is prosecuted the judge looks at the defendant and his tiny CB set and asks mildly what is the harm? It's sometimes difficult to convince the court that a serious offence has been committed. After all, it's not murder. No worse than parking over the allotted time on a meter. Or speeding. Everybody does it. The crime is to get caught.

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Policing of the New Zealand Citizens Band has been helped by the Australian authorities going back for many years.

Way back in 1969, reports from monitoring stations and from other sources had revealed that unlicensed Australian stations had formed an organised but illegal group of radio hobbyists who inter-communicated sporadically and who were most careful during transmissions to disguise both their identity and their location. A large number of these contacts were with New Zealand stations.

To complete the legal, or illegal, QSO, QSL cards are available in New Zealand. For postcard size, minimum order 300, cost $8.75.

Aerial housie games were once played by up to 64 members of the Taranaki Citizens Band Club — until they were closed down by the Roger Indias.

There has been introduced into New Zealand, as in Australia, a Novice Amateur Examination with a simple technical content and a slow morse test at only 6 words a minute which the New Zealand Association of Radio Transmitters, the equivalent of the WIA, hopes will provide for CBers who want to make the transition to the 'real world of radio'.

There are CB clubs and groups in most places, some taking their name from the town or city, others with names like 'Socially 11 Metres', 'Windy City CB Radio', 'Good Guys CB Social Group'.

CB people have banded together into groups such as IMPACT — Integrated Mobile Public Assistance Communications Team — to act as a link in the case of auto accidents, to assist CBers and others in the case of fire, earthquake or other natural disaster, to assist police to get word in case of crimes seen by CBers and any other form of assistance where life or property is at risk.

But at least New Zealand does have a CB service, and half a watt is better than no watt, to paraphrase, even if there is no butter or jam on the slice doled out.

CB SUPPLIERS

ACE RADIO	136 Victoria Rd, MARRICKVILLE 2004	NSW
AERO ELECTRONICS	Shop 13, 191 Ramsgate Road, RAMSGATE	NSW
AMATEURS' PARADISE	121Nerang St. SOUTHPORT 4215	QLD
AURIEMA	PO Box 604, BROOKVALE, 2100	NSW
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DEITCH BROS.	70 Oxford St., SYDNEY 2010	NSW
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	125 York Street, SYDNEY 2000	NSW
	361 Hume Highway, BANKSTOWN	NSW
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	656 Bridge Road, RICHMOND	VIC
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	760 George Street, SYDNEY 2000	NSW
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VICOM	139 Auburn Rd., AUBURN 3123	VIC
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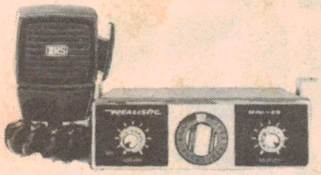
At time of printing it had been announced licencing of CB transceivers will commence July 1, 1977. It was also stated that channels 1 to 4,10,21 and 23 are prohibited from use on current USA 23 channel sets.

Even More Realistic CB Values



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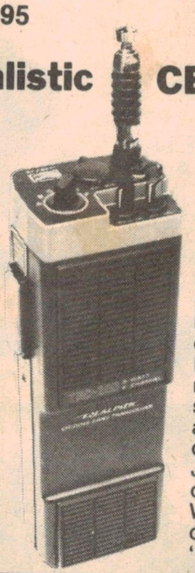

6 Channel 5 Watt Input

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the output transistor(s) are included in the negative feedback loop of the circuit. Consequently, the 600mV knee voltage of each junction is effectively reduced by a factor equal to the open-loop gain of the op-amp, so the junctions do not adversely effect the voltage-following characteristics of either circuit.

The Fig. 13a circuit is able to source current only, and can be regarded as a unidirectional, positive-going, d.c. voltage follower. The Fig. 13b circuit can both source and sink output currents, and thus gives bidirectional follower action. Each circuit has a current-driving capacity of about 50mA. This figure is dictated by the limited power rating of the specified output transistors. The drive capability can be increased by using alternative transistors.

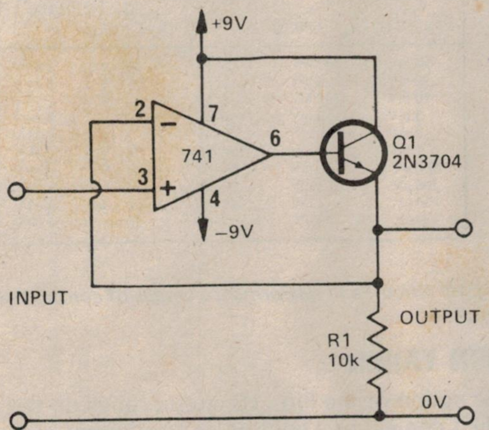


Fig. 13a Unidirectional d.c. voltage follower with boosted output (variable from 0V to +8V at 50mA.)

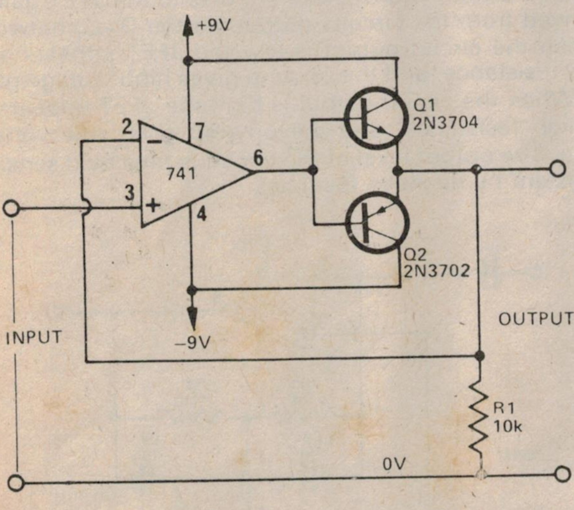


Fig. 13b Bidirectional d.c. voltage follower with boosted output (variable from 0V to± ±8V at 50mA).

MISC AMP PROJECTS (Figs. 14 to 22)

Figs. 14 to 22 show a miscellaneous assortment of 741 amplifier projects, ranging from d.c. adding circuits to frequency-selective amplifiers.

Fig. 14 shows the circuit of a unity-gain inverting d.c. adder, which gives an output voltage that is equal to the sum of the three input voltages. Here, input resistors R_1 to R_3 and feedback resistor R_4 each have the same value, and the circuit thus acts as a unity-gain inverting d.c. amplifier between each input terminal and the output. Since the current flowing in each input resistor also flows in feedback resistor R_4, the total current flowing in R_4 is equal to the sum of the input currents, and the output voltage is equal to the negative sum of the input voltages. The circuit is shown with only three input connections, but in fact can be provided with any number of input terminals. The circuit can be made to function as a so-called 'audio mixer' by wiring blocking capacitors in series with each input terminal and with the output terminal.

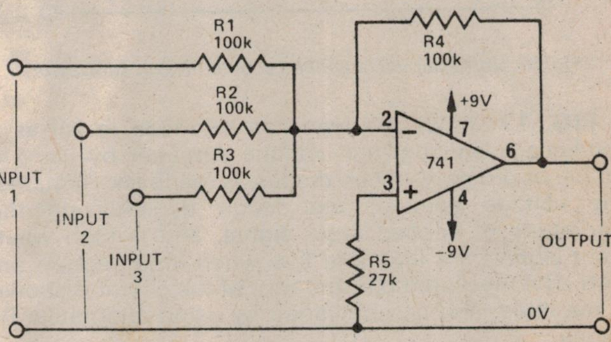


Fig. 14 Unity-gain inverting d.c. adder, or 'audio mixer'.

FIG. 15 shows how two unity-gain inverting d.c. amplifiers can be wired in series to make a precision unity-gain balanced phase-splitter. The output of the first amplifier is an inverted version of the input signal, and the output of the second amplifier is a non-inverted version.

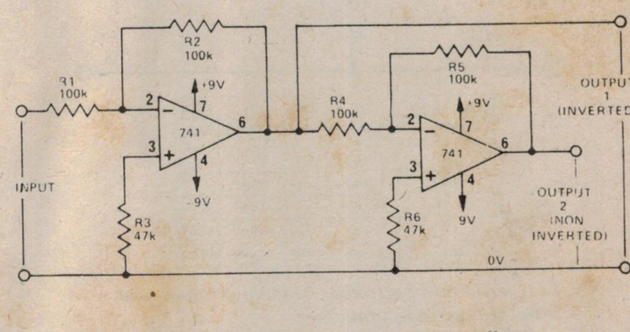


Fig. 15 Unity-gain balanced d.c. phase-splitter.

FIG. 16 shows how a 741 can be used as a unity-gain differential d.c. amplifier. The output of this circuit is equal to the difference between the two input signals or voltages, or to e_1-e_2. Thus, the circuit can also be used as a subtractor. In this type of circuit the component values are chosen such that $R_1/R_2=R_4/R_3$, in which case the voltage gain $A_v=R_2/R_1$. The circuit can thus be made to give voltage gain if required.

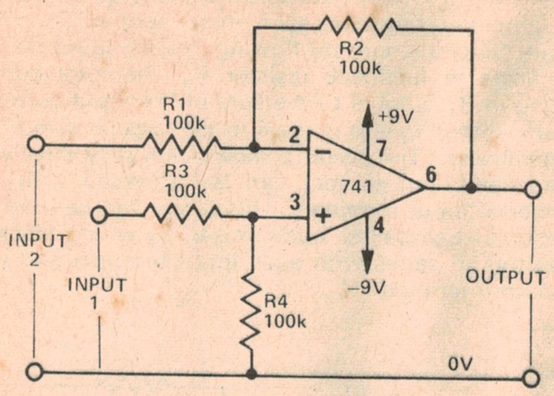
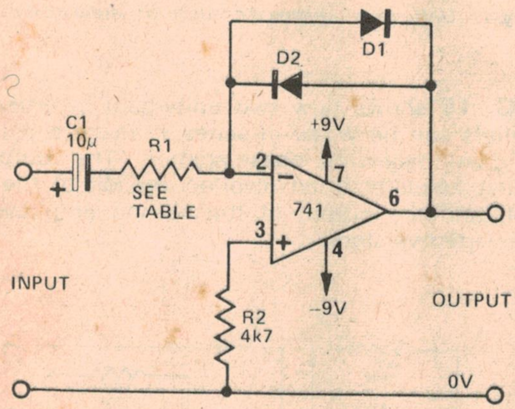


Fig. 16 Unity-gain differential d.c. amplifier, or subtractor.

FIG. 17 shows the amp can be made to act as a non-linear (semi-log) a.c. voltage amplifier by using a couple of ordinary silicon diodes as feedback elements. The voltage gain of the circuit depends on the magnitude of applied input signal, and is high when input signals are low, and low when input signals are high. The measured performance of the circuit is shown in the table, and can be varied by using alternative R_1 values.

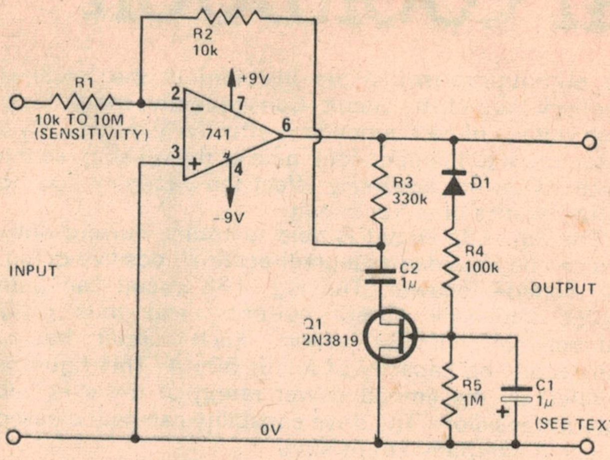


INPUT VOLTS (RMS)	R_1 = 1kΩ		R_1 = 10kΩ	
	V_{OUT} (R M S)	GAIN	V_{OUT} (RMS)	GAIN
1 mV	110 mV	X 110	21 mV	X 21
10 mV	330 mV	X 33	170 mV	X 17
100 mV	450 mV	X4 5	360 mV	X 3 6
1V	560 mV	X0 56	470 mV	X 0 47
10V	600 mV	X0 07	560 mV	X0 056

Fig. 17 Circuit and performance table of non-linear (semi-log) a.c. voltage amplifier.

FIG. 18 shows how the 741 can be used together with a junction-type field-effect transistor (JFET) to make a so-called constant-volume amplifier. The action of this type of circuit is such that its peak output voltage is held sensibly constant, without distortion, over a wide range of input signal levels, and this particular circuit gives a sensibly constant output over a 30dB range of input signal levels.

The measured performance of the circuit is shown in the table. C_1 determines the response time of the amplifier, and may be altered to satisfy individual needs.



V_{IN} (R_1 = 10KΩ)	V_{IN} (R_1 = 100KΩ)	V_{IN} (R_1 = 1MΩ)	V_{IN} (R_1 = 10MΩ)	V_{OUT}
50 mV	500 mV	5 V	50 V	2.85 V
20 mV	200 mV	2 V	20 V	2.81 V
10 mV	100 mV	1 V	10 V	2.79 V
5 mV	50 mV	500 mV	5 V	2.60 V
2 mV	20 mV	200 mV	2 V	2.03 V
1 mV	10 mV	100 mV	1 V	1.48 V
500 µV	5 mV	50 mV	500 mV	0.89 V
200 µV	2 mV	20 mV	200 mV	0.40 V
100 µV	1 mV	10 mV	100 mV	0.20 V
50 µV	500 µV	5 mV	50 mV	0.10 V

Fig. 18 Circuit and performance details of constant-volume amplifier.

ACTION TAKEN

The action of the Fig. 18 circuit relies on the fact that the JFET can act as a voltage-controlled resistance which appears as a low value when zero bias is applied to its gate and as a high resistance when its gate is negatively biased. The JFET and R_3 act as a gain-determining a.c. voltage divider (via C_2), and the bias to the JFET gate is derived from the circuits output via the D_1-C_1 network. When the circuit output is low the JFET appears as a low resistance, and the op-amp gives high voltage gain.

When the circuit output is high the JFET appears as a high resistance, and the op-amp gives low voltage gain. The output level of the circuit is thus held sensibly constant by negative feedback.

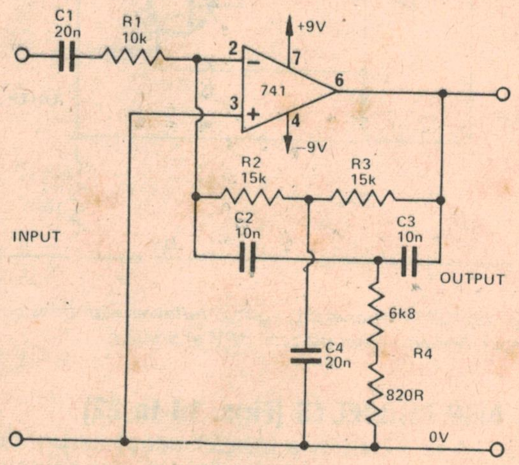


Fig. 19 1kHz tuned (acceptor) amplifier (twin-T).

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The 741 op-amp can be made to function as a frequency-selective amplifier by connecting frequency-sensitive networks into its feedback loops. Fig. 19 shows how a twin-T network can be connected to the op-amp so that it acts as a tuned (acceptor) amplifier, and Fig. 20 shows how the same twin-T network can be connected so that the op-amp acts as a notch (rejector) filter. The values of the twin-T network are chosen such that $R_2=R_3=2 \times R_4$, and $C_2=C_4/2$, in which case its centre (tuned) frequency $=1/6.28\ R_2.C_2$. With the component values shown, both circuits are tuned to approximately 1kHz.

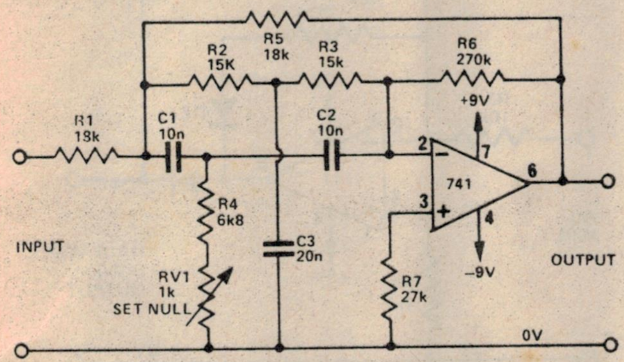

Fig. 20 1kHz notch (reject) filter.

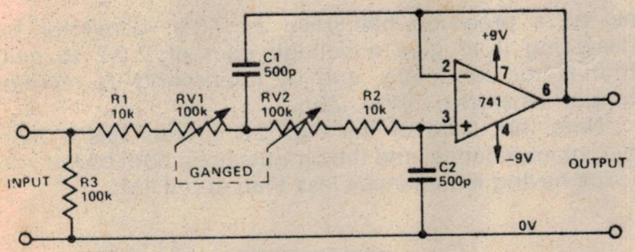

Fig. 21 Variable low-pass filter, covering 2.2kHz to 24kHz.

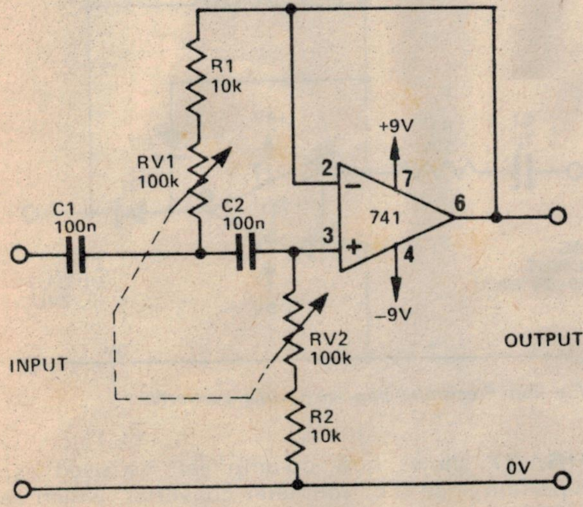

Fig. 22 Variable high-pass filter, covering 235Hz to 2.8kHz.

Finally, to complete this section, Figs. 21 and 22 show the circuits of a couple of variable-frequency audio filters. The Fig. 21 circuit is that of a low-pass filter which covers the range 2.2kHz to 24kHz, and the Fig. 22 circuit is that of a high-pass filter which covers the range 235Hz to 2.8kHz. In each case, the circuit gives unity gain to signals beyond its cut-off frequency, and gives a 2nd order response (a change of 12dB per octave) to signals within its range.

INSTRUMENTATION PROJECTS (Figs. 23 to 31)

Figs. 23 to 31 show a variety of instrumentation projects in which the 741 can be used. The circuits range from a simple voltage regulator to a linear-scale ohmmeter.

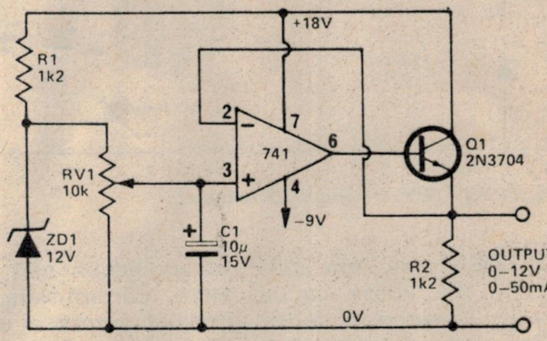

Fig. 23 Simple variable-voltage supply.

FIG. 23 shows the circuit of a simple variable-voltage power supply, which gives a stable output that is fully adjustable from 0V to 12V at currents up to a maximum of about 50mA. The operation of the circuit is quite simple. ZD_1 is a zener diode, and is energised from the positive supply line via R_1. A constant reference potential of 12V is developed across the zener diode, and is fed to variable potential divider RV_1.

The output of this divider is fully variable from 0V to 12V, and is fed to the non-inverting input of the op-amp. The op-amp is wired as a unity-gain voltage follower, with Q_1 connected as an emitter follower current-booster stage in series with its output.

Thus, the output voltage of the circuit follows the voltage set at the op-amp input via RV_1, and is fully variable from 0V to 12V. Note that the circuit uses an 18V positive supply and a 9V negative supply.

Also note that the voltage range of the above circuit can be increased by using higher zener and unregulated supply voltages, and that its current capacity can be increased by using one or more power transistors in place of Q_1.

FIG. 24 shows how a 741 op-amp can be used as the basis of a stabilised power supply unit (P.S.U.) that covers the range 3V to 30V at currents up to 1A. Here, the voltage supply to the op-amp is stabilized at 33V via ZD_1, and a highly temperature-stable reference of 3V is fed to the input of the op-amp via ZD_2.

The op-amp and output transistors Q_1-Q_2 are wired as a variable-gain non-inverting d.c. amplifier, with gain variable from unity to x10 via RV_1, and the output voltage is thus fully variable from 3V to 30V via RV_1. The output voltage is fully stabilized by negative feedback.

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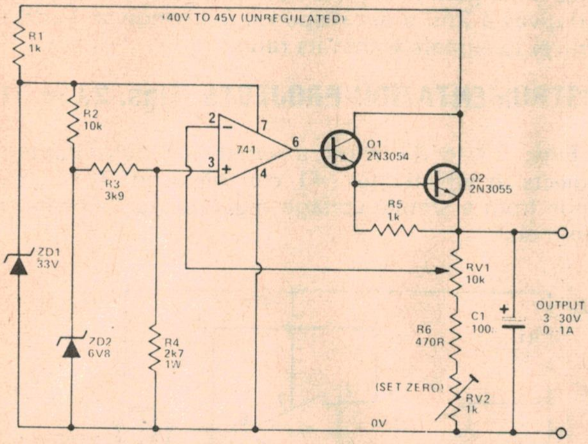

Fig. 24 3V - 30V, 0-1 amp stabilised p.s.u.

FIG. 25 shows how overload protection can be applied to the above circuit. Here, current-sensing resistor R_7 is wired in series with the output of the regulator, and cut-out transistor Q_3 is driven from this resistor and is wired so that its base-collector junction is able to short the base-emitter junction of the Q_1-Q_2 output transistor stage.

Normally, Q_3 is inoperative, and has no effect on the circuit, but when P.S.U. output currents exceed 1A a potential in excess of 600mV is developed across R_7 and biases Q_3 on, thus causing Q_3 to shunt the base-emitter junction of the Q_1-Q_2 output stage and hence reducing the output current. Heavy negative feedback takes place in this action, and the output current is automatically limited to 1A, even under short-circuit conditions.

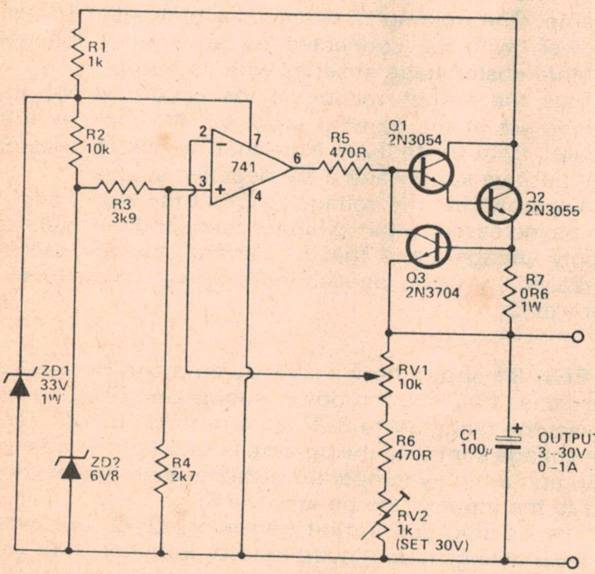

Fig. 25 3V - 30V stabilised p.s.u. with overload protection.

FIG. 26a shows how a 741 can be used in conjunction with a couple of silicon diodes as a precision half-wave rectifier. Conventional diodes act as imperfect rectifiers of low-level a.c. signals, because they do not begin to conduct significantly until the applied signal voltage exceeds a 'knee' value of about 600mV.

When diodes are wired into the negative feedback loop of the circuit as shown the 'knee' voltage is effectively reduced by a factor equal to the open-loop gain of the op-amp, and the circuit thus acts like a near-perfect rectifier.

The overall voltage gain of the Fig. 26a circuit is dictated by the ratios of R_1 and R_2 to R_3, as in the case of a conventional inverting amplifier, and this circuit thus gives a gain of unity. The circuit can be made to

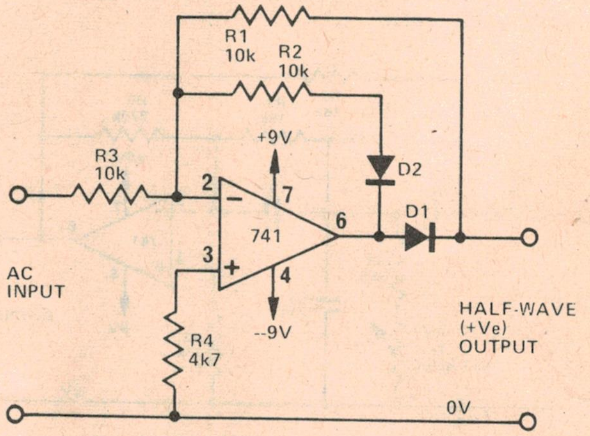

Fig. 26a Precision unity-gain half-wave rectifier.

act as a precision half-wave a.c./d.c. converter by designing it to give a voltage gain of 2.22 to give form-factor correction, and by integrating its rectifier output, as shown in Fig. 26b.

Note that each of the Fig. 26 circuits has a high output impedance, and the outputs must both be fed into loads having impedances less than about 1M.

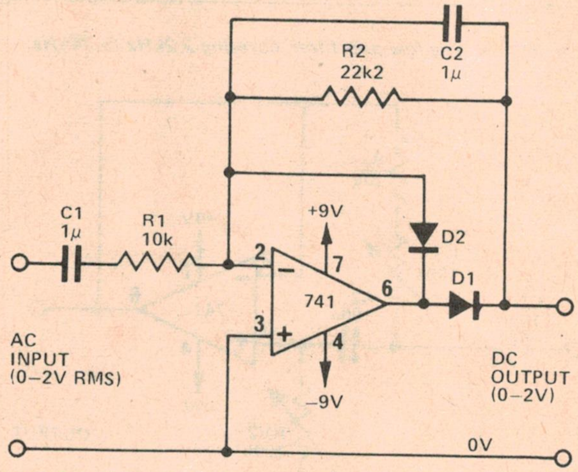

Fig. 26b Precision half-wave a.c./d.c. converter.

FIG. 27 shows how op-amp can be used as a high-performance d.c. voltmeter converter, which can be used to convert any 1V f.s.d. meter with a sensitivity better than 1k/V into a voltmeter that can read any

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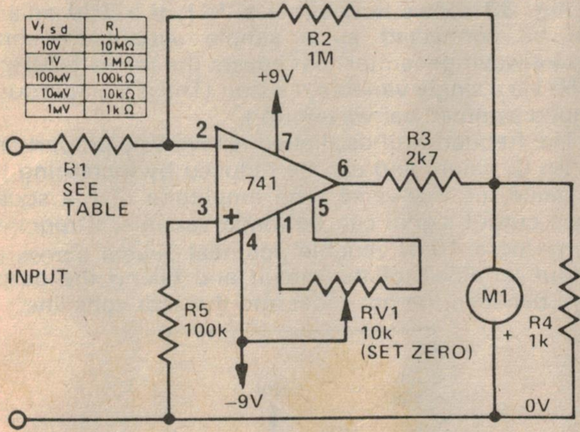
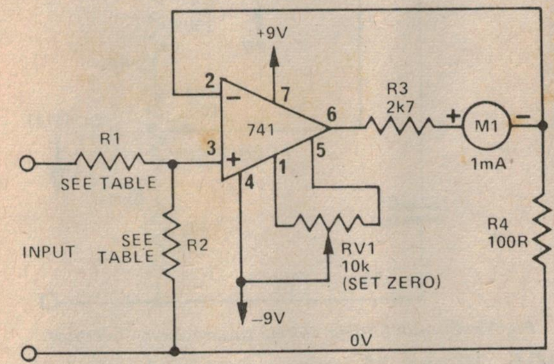
value in the range 1mV to 10V f.s.d. at a sensitivity of 1M/V. The voltage range is determined by the R_1 value, and the table shows some suitable values for common voltage ranges.

FIG. 28 shows a simple circuit that can be used to convert a 1mA f.s.d. meter into a d.c. voltmeter with any f.s.d. value in the range 100mV to 1000V, or into a d.c. current meter with any f.s.d. value in the range 1uA to 1A. Suitable component values for different ranges are shown in the tables.



V_{fsd}	R_1
10V	10MΩ
1V	1MΩ
100mV	100kΩ
10mV	10kΩ
1mV	1kΩ

Fig. 27 High-performance d.c. voltmeter converter.



VOLTMETER		
f.s.d	R_1	R_2
1000V	10MΩ	1kΩ
100V	10MΩ	10kΩ
10V	10MΩ	100kΩ
1V	900kΩ	100kΩ
100mV	0Ω	100kΩ

CURRENT METER		
f.s.d	R_1	R_2
1A	0Ω	0.1Ω
100mA	0Ω	1Ω
10mA	0Ω	10Ω
1mA	0Ω	100Ω
100μA	0Ω	1kΩ
10μA	0Ω	10kΩ
1μA	0Ω	100kΩ

Fig. 28 Simple d.c. voltage or current meter.

FIG. 29 shows the circuit of a precision d.c. millivoltmeter, which uses a 1mA f.s.d. meter to read f.s.d. voltages from 1mV to 1000mV in seven switch-selected ranges.

FIG. 30 shows the basic circuit of a precision a.c. volt or millivolt meter. This circuit can be used with any moving-coil meter with a full scale current value in the range 100uA to 5mA, and can be made to give any full scale a.c. voltage reading in the range 1mV to 1000mV. The tables show the alternative values of R_1 and R_2 that must be used to satisfy different basic meter sensitivities, and the values of R_3 and R_4 that must be used for different f.s.d. voltage sensitivities.

HOME OHM

Finally, to conclude, Fig. 31 shows how the 741 op-amp can be used in conjuncton with a 1mA f.s.d. meter to make a linear-scale ohmmeter that has five decade ranges from 1k to 10M.

The circuit is divided into two parts, and consists of a voltage generator that is used to generate a standard test

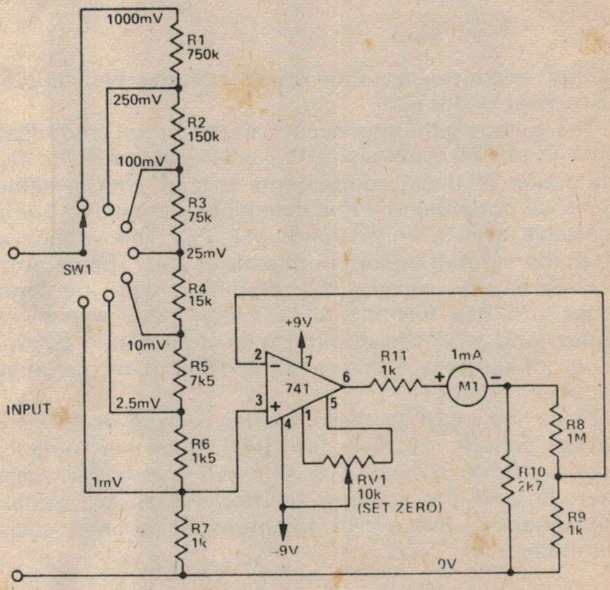
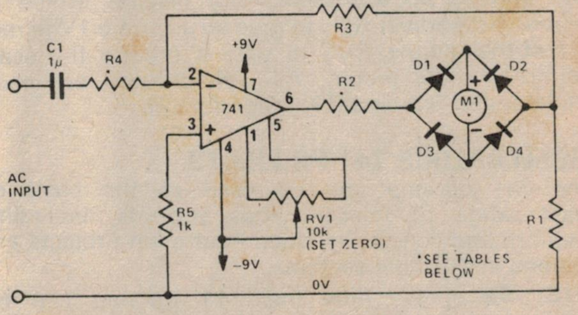


Fig. 29 Precision d.c. millivoltmeter.



M_1	R_1	R_2
100μA	9kΩ	27kΩ
500μA	1.8kΩ	5.6kΩ
1mA	900Ω	2.7kΩ
2.5mA	360Ω	1.5kΩ
5mA	180Ω	470Ω

VALUES FOR USE WITH DIFFERENT METER MOVEMENTS

V_{fsd}	R_4	R_3
1000V	10MΩ	10kΩ
100V	10MΩ	100kΩ
10V	10MΩ	1MΩ
1V	1MΩ	1MΩ
100mV	100kΩ	1MΩ
10mV	10kΩ	1MΩ
1mV	1kΩ	1MΩ

DIFFERENT f.s.d VOLTAGE SENSITIVTIES

Fig. 30 Precision a.c. volt/millivolt meter.

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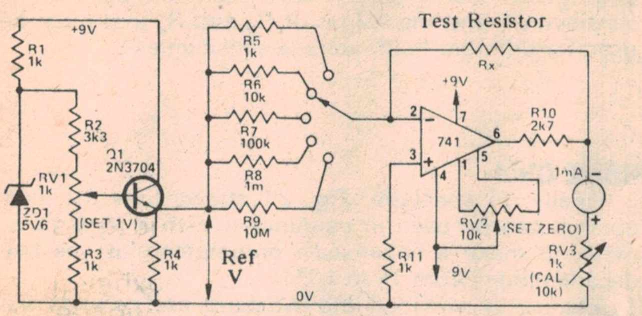

Fig. 31 Linear-scale ohmmeter.

voltage, and a readout unit which indicates the value of the resistor under test.

The voltage generator section of the circuit comprises zener diode ZD_1, transistor Q_1, and resistors R_1 to R_4. The action of these components is such that a stable reference potential of 1V is developed across R_4, but is adjustable over a limited range via RV_1. This voltage is fed to the input of the op-amp readout unit. The op-amp is wired as an inverting d.c. amplifier, with the 1mA meter and RV_3 forming a 1V f.s.d. meter across its output, and with the op-amp gain determined by the values of ranging resistors R_5 to R_9 and by negative feedback resistor R_x.

Since the input to the amplifier is fixed at 1V, the output voltage reading of the meter is directly proportional to the value of R_x, and equals full scale when R_x and the ranging resistor values are equal. Consequently, the circuit functions as a linear-scale ohmmeter.

CALIBRATION

The procedure for initially calibrating the Fig. 31 circuit is as follows: First, switch the unit to 10k range and fix an accurate 10kΩ resistor in the R_x position. Now adjust RV_1 to give an accurate 1V across R_4, and then adjust RV_2 to give a precise full scale reading on the meter. All adjustments are then complete, and the circuit is ready for use.

MISCELLANEOUS 741 PROJECTS

The 741 op-amp can be used as the basis of a vast range of miscellaneous projects, including oscillators and sensing circuits. Four such projects are described in this final section.

FIG. 32 shows how the 741 op-amp can be connected as a variable-frequency wien-bridge oscillator, which covers the basic range 150Hz to 1.5kHz, and uses a low-current lamp for amplitude stabilisation. The output amplitude of the oscillator is variable via RV_4 and has a typical maximum value of 2.5V r.m.s. and a t.h.d. value of 0.1%. The frequency range of the circuit is inversely proportional to the C_1-C_2 values. The circuit can give a useful performance up to a maximum frequency of about 25kHz.

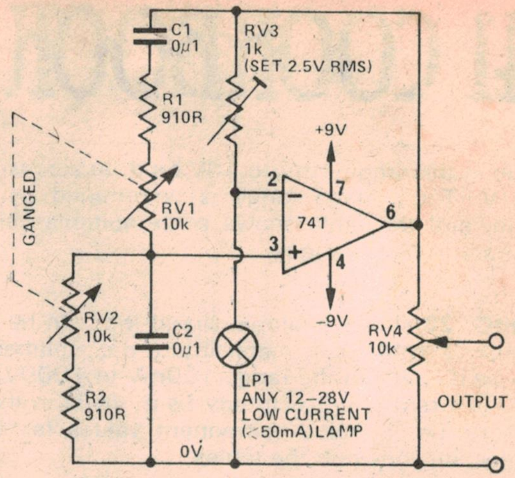

Fig. 32 150Hz - 1.5kHz Wien-bridge oscillator.

Fig. 33 shows how either a 741 or a 709 op-amp can be connected as a simple variable-frequency square-wave generator that covers the range 500Hz to 5kHz via a single variable resistor. (The circuit produces a good symmetrical waveform.)

The frequency of oscillation is inversely proportional to the C_1 value, and can be reduced by increasing the C_1 value, or vice-versa. The amplitude of the square wave output signal can be made variable, if required, by wiring a 10kΩ variable potential divider across the output terminals of the circuit and taking the output from between the pot slider and the zero volts line.

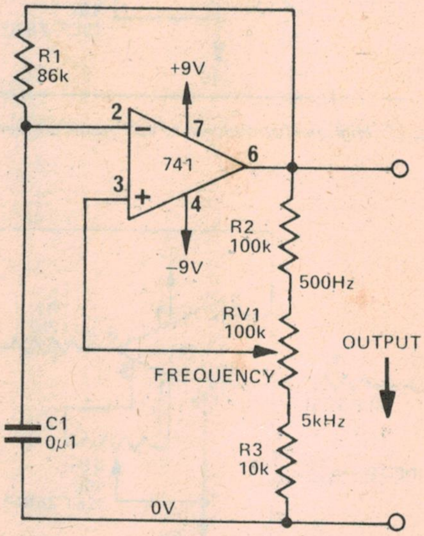

Fig. 33 Simple 500Hz - 5kHz square wave generator.

FIGS. 34 and 35 show a couple of useful ways of using the 741 op-amp in the open-loop differential voltage comparator mode. In each case, the circuits are powered from single-ended 12V supplies, and have a fixed half-supply reference voltage applied to the non-inverting op-amp terminal via the R_1-R_2 potential divider and have a variable voltage applied to the inverting op-amp terminal via a variable potential divider.

The circuit action is such that the op-amp output is driven to negative saturation (and the relay is driven on) when the variable input voltage is greater than the reference voltage. Conversely, the op-amp output is driven to positive saturation (and the relay is cut off) when the variable input voltage is less than the reference voltage.

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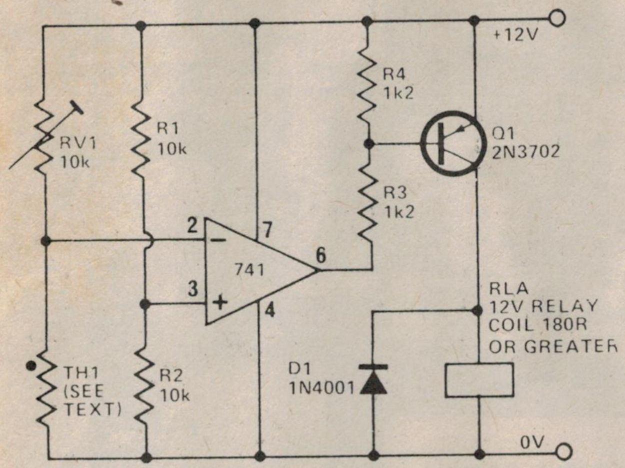

Fig. 34 Precision frost or under temperature switch can be made to act as a fire or over temperature switch by transposing R_1 and TH_1 positions.

FROSTY RECEPTION

The Fig. 34 circuit is that of a precision frost or under-temperature switch, which drives the relay on when the temperature sensed by thermistor TH_1 falls below a value pre-set via RV_1. The circuit action can be reversed, so that it operates as a fire or over-temperature switch, by simply transposing the RV_1 and the TH_1 positions. In either case, TH_1 can be any negative-temperature-coefficient thermistor that presents a resistance in the range 900Ω to 9kΩ at the required trip temperature.

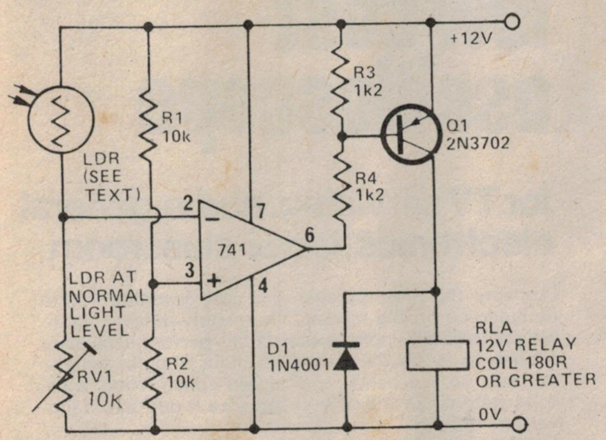

Fig. 35 Precision light-activated switch can be made to act as a dark-activated switch by transposing R_1 and LDR positions.

LIGHT WORK

The Fig. 35 circuit is that of a precision light-activated switch, which turns the relay on when the illumination level sensed by light-dependent resistor LDR exceeds a value pre-set by RV_1. The circuit action can be reversed so that the relay turns on when the illumination falls below a pre-set level by simply transposing the RV_1 and LDR positions. In either case, the LDR can be any cadmium-sulphide photocell that presents a resistance in the range 900Ω to 9kΩ at the desired switch-on level.●

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CAPACITORS

Ceramics: All preferred values from 1pf to 0.033 uF. 8c each 25 up 6c ea. 0.047 to 0.1 uF. 15c ea. 25 up 10ea. 0.47 uFd 29c ea. 25 up 23c ea.

C/MOS

4000	33	4016	58
4001	33	4017	1.33
4002	33	4018	1.33
4006	1.33	4021	1.33
4007	33	4022A	1.33
4008	1.40	4023A	33
4009	64	4024	1.03
4011	33	4027A	63
4012	33	4028A	1.03
4013	55	4030A	58
4014	1.33		

TRANSISTORS

BC547	20	BC640	30
BC548	20	BD139	59
BC549	20	BD140	59
BC559	20	BF180	59
BC639	30		

TTL DIGITAL / LINEAR

TTL DIGITAL		LINEAR	
T.T.L.		LM301	50
Digital		LM307	70
7400	26	LM308	1.30
7402	26	LM309K	1.95
7404	30	LM324	2.24
7408	28	LM339	1.55
7410	26	LM377	1.95
7420	26	LM380	1.30
7430	26	LM382	1.30
7447	$1.26	LM3900	1.10
7451	26	LM555	57
7454	26	LM566	2.29
7474	26	LM709	45
7490	65	LM723	55
7492	65	LM741	45
74107	45	LM1458	72

ELECTROLYTICS

Value	Voltage				
1 uFd	6.3 Axial	13	100 uFd	25 p.c.b.	15
2.2 uFd	25 p.c.b.	8	220 uFd	6.3 p.c.b.	17
3.3 uFd	25 p.c.b.	8	220 uFd	16 p.c.b.	17
4.7 uFd	10 p.c.b.	8	220 uFd	35 p.c.b.	22
4.7 uFd	25 p.c.b.	8	470 uFd	6.3 p.c.b.	22
22 uFd	10 p.c.b.	8	470 uFd	25 p.c.b.	22
22 uFd	50 p.c.b.	15	1000 uFd	10 Axial	35
25 uFd	16 p.c.b.	8	1000 uFd	16 p.c.b.	36
33 uFd	6.3 p.c.b.	9	1000 uFd	25 p.c.b.	47
33 uFd	16 p.c.b.	10	1000 uFd	35 p.c.b.	47
47 uFd	10 p.c.b.	12	1000 uFd	50 p.c.b.	80
47 uFd	25 p.c.b.	14	2200 uFd	50 upright	$1.60
47 uFd	50 p.c.b.	15	3300uFd	50 upright	$1.75
100 uFd	10 p.c.b.	13	3300 uFd	75 upright	$2.40

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TK/11

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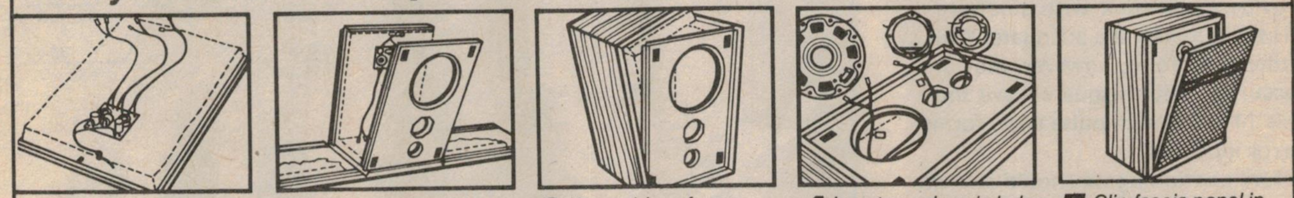

1 Screw the crossover networks to the baffle boards.

2 Apply glue to the case and fit baffle boards in grooves.

3 Wrap sides of case around baffle board.

4 Insert speakers in holes and screw into position.

5 Clip fascia panel in place.

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TRUE RMS VOLTMETER

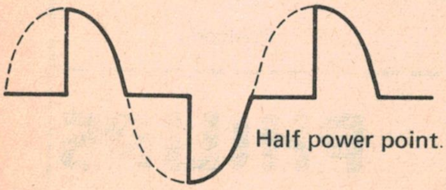
The use of a special IC results in performance greatly improved over conventional designs.

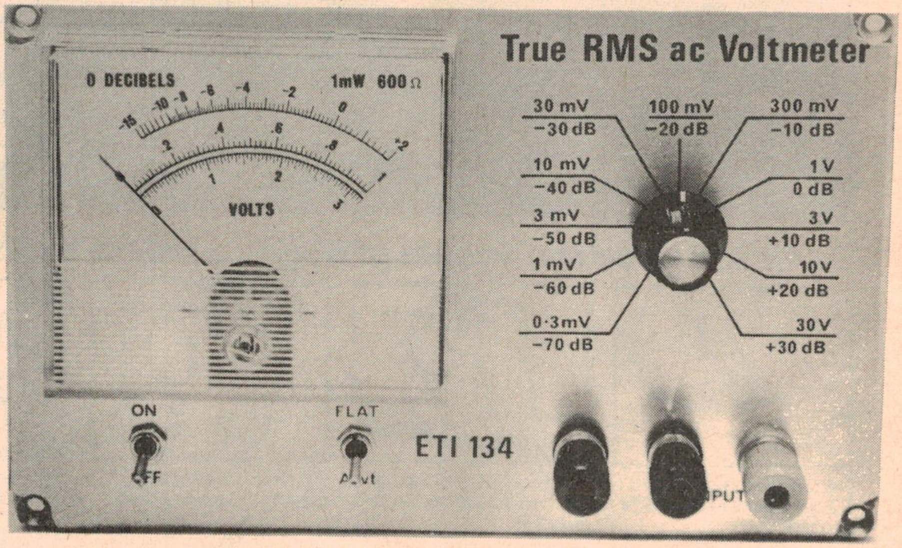
MOST METERS which can measure ac signals do so by rectifying the signal and then measuring the average voltage. With a sinewave the average voltage is 0.637 of the peak voltage while the rms value is 0.707 of the peak. Therefore a correction factor of 1.11 is built into the meter to give the rms value of the signal.

Provided you stick with sinewave signals these meters are adequate. With any other waveform, however, they are not accurate. With a square wave the error is 11% and with pulse wave forms the error increases.

Before continuing we should explain what rms means and its significance. Without getting mathematical, the rms value of any wave form is the same as a dc value which would produce the same heating effect in a resistor. For example:

Power in a load can be varied by using phase control (i.e., light dimmer) where the time the load is connected to the mains is variable. The rms value is difficult to calculate except at the point where it is half on—half off. The power then is obviously half power.





If the input voltage is 240 V and the load is 240 ohms the power (maximum) is given by

$$P = \frac{E^2}{R} \text{ or } \frac{240 \times 240}{240} = 240 \text{ W}$$

Half power therefore is 120 W. The voltage corresponding to this is given by

$$E = \sqrt{P \times R} \text{ or } 170 \text{ V (rms)}$$

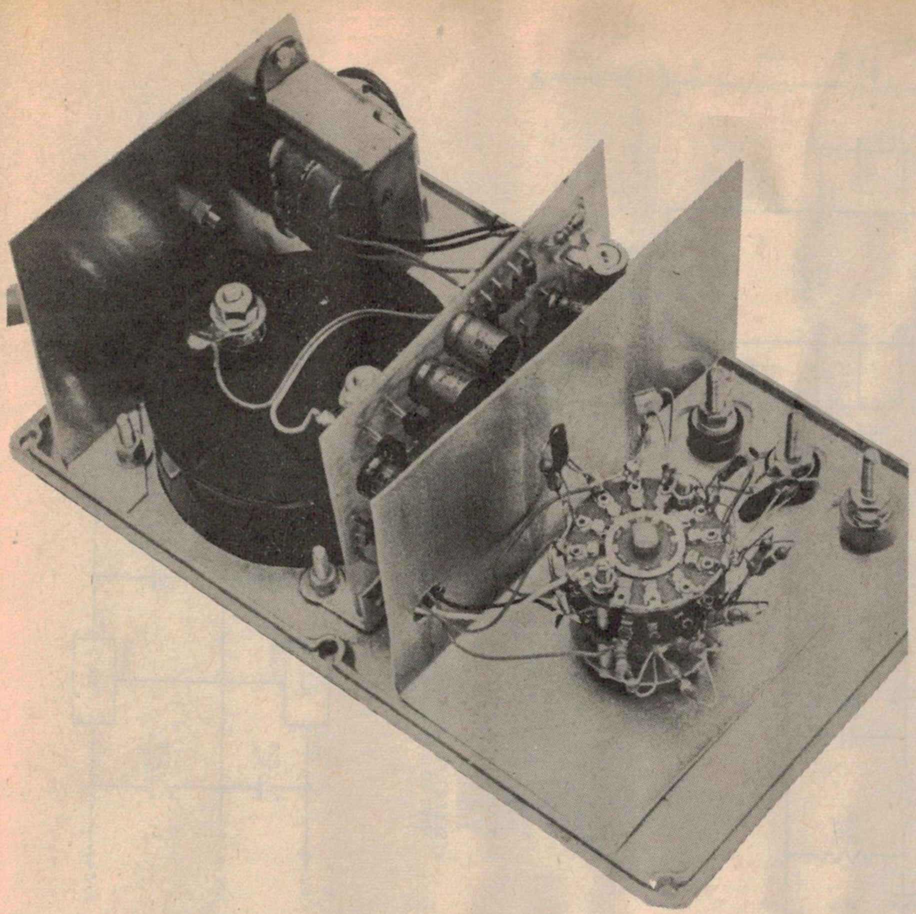
On a "normal" meter this will read 120 V or an error of 30%.

This design uses an rms detector IC, which is basically a small, special-purpose analogue computer to mathematically calculate the true rms value for any waveform.

Design Features

The design of the voltmeter is basically simple, starting with an attenuator in the front end, then an amplifier with a high input impedance and switchable gain which, with the attenuator, gives the range selection. A filter is then added to give the "A" weighting and the rms detector IC (LH0091) does the rest.

The output of the input amplifier is 60 mV, independent of range selected, for an input corresponding to the full scale reading. This gives a maximum gain of 46 dB on the 0.3 mV range. There is a loss of about 2.3 dB in the filter (at 1 kHz) and the spare amplifier in IC2 is used to provide a gain of 20 dB giving 500 mV (for full scale reading) before the rms detection is done. The



rms detector section has unity gain with 500 mV rms in giving 500 mV dc out.

However things are never that simple. With a total of 60-odd dB gain, along with the requirement for a 1 M input impedence, we have an excellent formula for an oscillator. With the third try (yes, we have failures too) with adequate shielding and layout, stability was obtained and this final design is presented here.

The spare IC in the LH0091 is normally used to buffer, filter or amplify the output of the rms converter (see data sheets in this issue) but we used it before so as to buffer the filter network and save an additional op amp (the input of the rms converter is only 5 k ohms). The output voltage from the converter is only 500 mV but this is adequate to drive a meter. We could have provided more gain in the buffer stage so giving a higher output but this would lead to greater errors with high crest factor waveforms.

We have limited this instrument to ac signals as this eliminates the need for balance controls to correct for drift when measuring low level signals. This normally is of no consequence as most signals, i.e., output of a tape recorder, sound level meter, etc., have no dc component. If dc capability is needed, capacitors C1, 8, 9, 14, 15 and 16 have to be shorted out, a zero adjustment potentiometer added to IC1 along with the potentiometers needed to offset adjust IC2 (see data sheet).

SPECIFICATION – ETI 134

Meter Type	rms reading ac only
Ranges	0.3, 1, 3, 10, 30, 100, 300 mV 1, 3, 10, 30 V
Accuracy	+3% nominal (crest factors up to 3) –8% at crest factory of 10
Input Impedance	1 megohm in parallel with 25 pF
Weighting Networks	Flat or 'A' weight
Frequency Response	10 Hz – 20 kHz

Construction

If the printed circuit board is used along with the layout and shields as described there should be no problems with construction. The wires associated with the rotary switch should be no longer than necessary to minimise any pickup. The box should be earthed to the mains earth and the front panel earth terminal (left hand one) should also be connected to earth.

Use

When measuring low level signals there may be 50 Hz pickup unless the common side of the input signal is connected to ground. This may be done either in the unit under test or on the meter (hence the earth terminal). Also with the meter terminals open circuited the meter will give some reading. However, as the output impedance of low level signals (0.3 mV and less) is normally relatively low this is normally no problem.

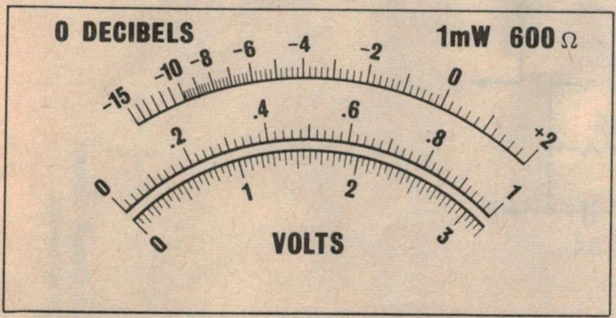


Fig. 1. Meter scale shown full size.

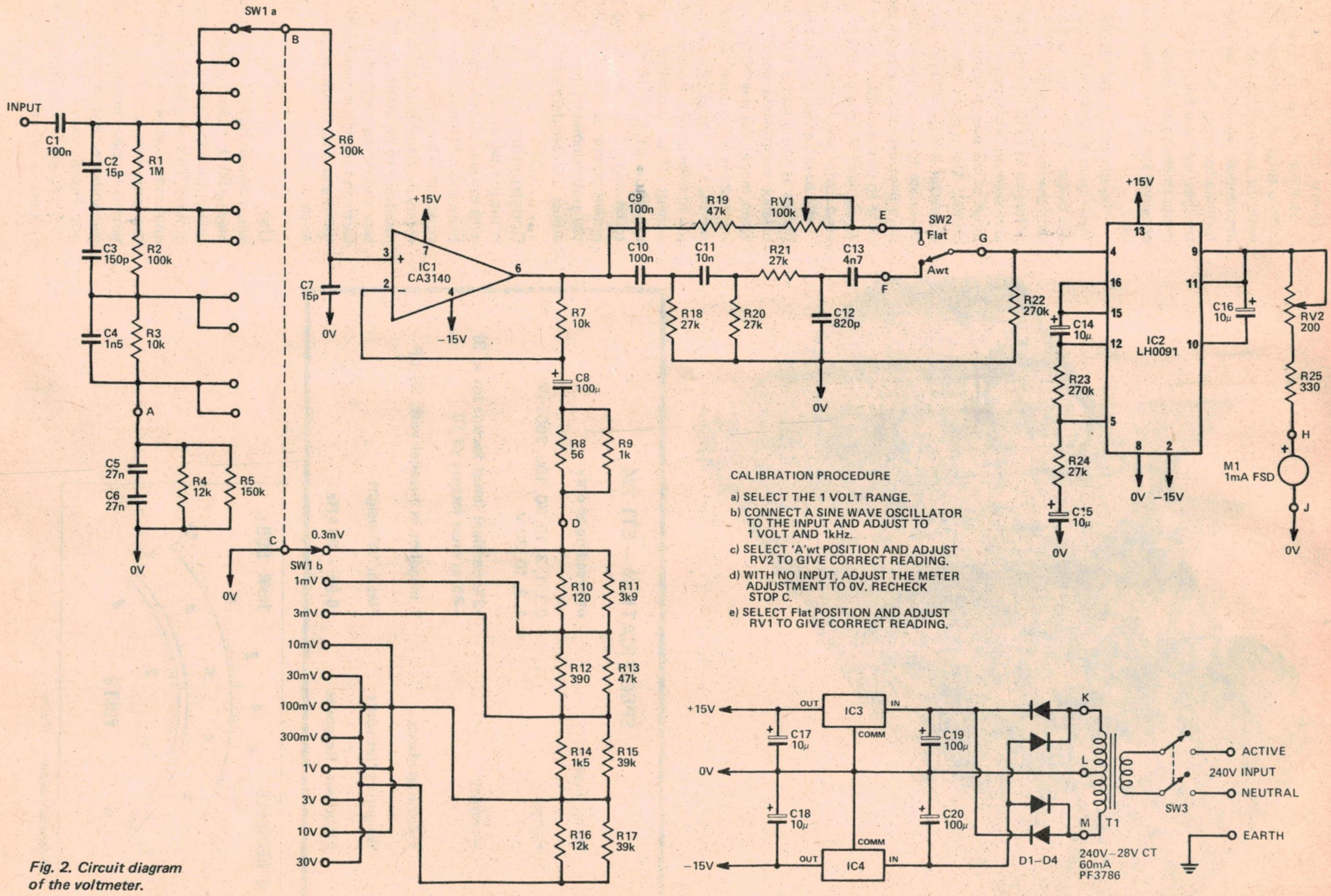


Fig. 2. Circuit diagram of the voltmeter.

HOW IT WORKS – ETI 134

The input signal is attenuated by the network R1–R5 and C2–C6; the appropriate attenuation is selected by SW1a. This gives 0 dB, 20 dB, 40 dB and 60 dB. The output of SW1a is buffered by IC1 which is a FET input op-amp. This amplifier has a gain which is switchable giving 5.56 dB, 15.56 dB, 25.56 dB, 35.56 dB and 45.56 dB. By selecting a combination of these two variables the eleven ranges from 0.3 mV to 30 V are obtained. The output of IC1 for full scale reading is 60 mV.

The output of IC1 goes to the 'A' wt filter network and also directly (via R19) and RV1) to SW2. This selects either 'A' weighting or flat response. As the filter has 2.3 dB loss at 1 kHz the "flat" position is also attenuated (hence R19, RV1) to maintain calibration.

The rms detector IC provides a gain of 20 dB before the detector; the output of the detector is about 500 mV for full scale reading.

The power supply is simply a full wave rectified supply giving both plus and minus voltages of about 20 V, which are then regulated to ±15 V by IC3 and IC4.

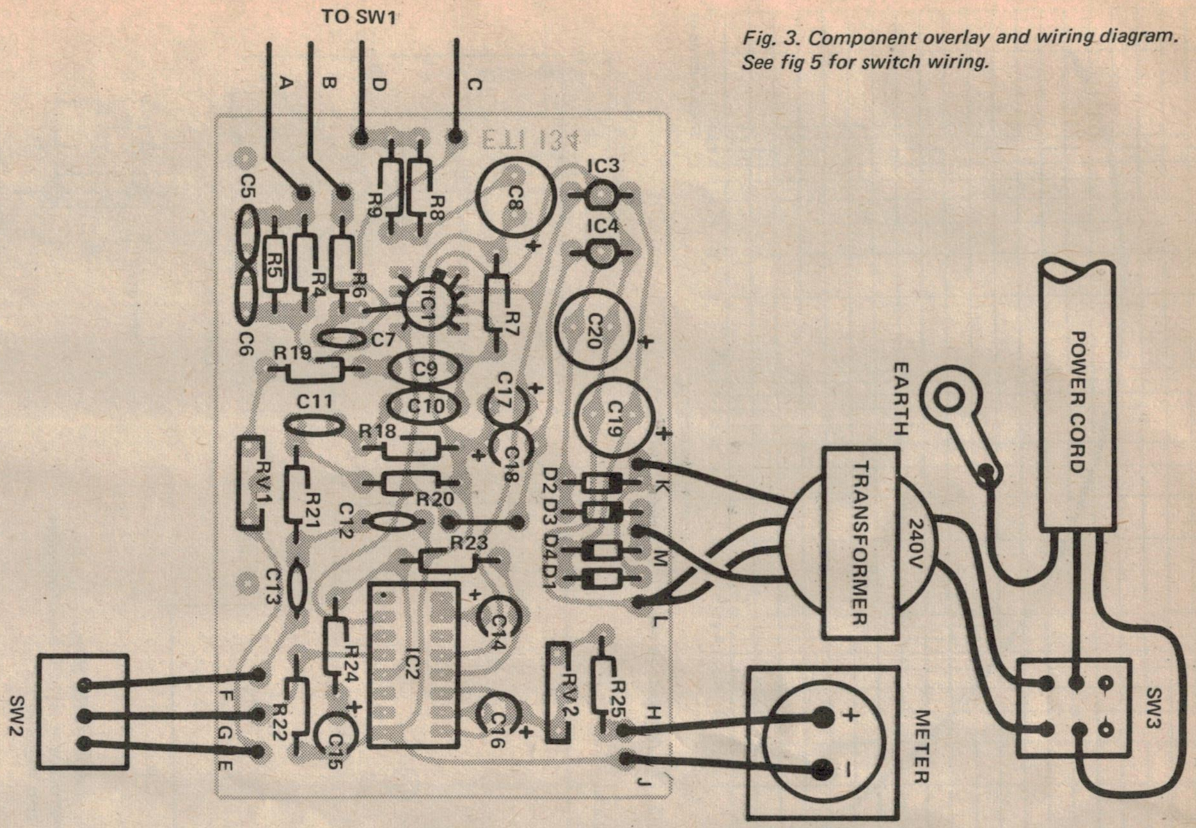


Fig. 3. Component overlay and wiring diagram. See fig 5 for switch wiring.

PARTS LIST - ETI 134

Resistors

All ½ W 5%, except where marked.

R1	1M	1%
R2	100k	1%
R3	10k	1%
R4	12k	1%
R5	150k	
R6	100k	
R7	10k	1%
R8	56	1%
R9	1k	
R10	120	1%
R11	3k9	
R12	390	1%
R13	47k	
R14	1k5	1%
R15	39k	
R16	12k	1%
R17	39k	2%
R18	27k	
R19	47k	
R20,21	27k	
R22,23	270k	
R24	27k	
R25	330	

Potentiometers

RV1	100k	trim
RV2	200 ohm	trim

Capacitors

C1	100n	polyester
C2*	15p	ceramic
C3*	150p	"
C4*	1n5	polyester
C5, 6*	27n	"
C7	15p	ceramic
C8	100µ	25V electro
C9, 10	100n	polyester
C11	10n	"
C12	820n	ceramic
C13	4n7	polyester
C14-C18	10µ	25V electro
C19, 20	100µ	25V electro

* These capacitors should be as accurate as possible as they affect accuracy above 10kHz.

Semiconductors

IC1	CA3140	op amp
IC2	LH0091	RMS converter
IC3	78L15	regulator
IC4	79L15	regulator
D1-D4	1N4001 or similar	

Miscellaneous

PC board	ETI 134
SW1	2 pole 11 position OAK switch
SW2	SPDT minature toggle switch
SW3	DPDT minature toggle switch
T1	Transformer PF3786 (28V ct)
M1	Meter 1mA scaled as shown

3 terminals (red, black green)
Box Eddystone 6357P
Metal brackets and shields (see Fig 7)
3 core flex and plug
Scotchcal or aluminium front panel
16 pin socket for IC2
Knob

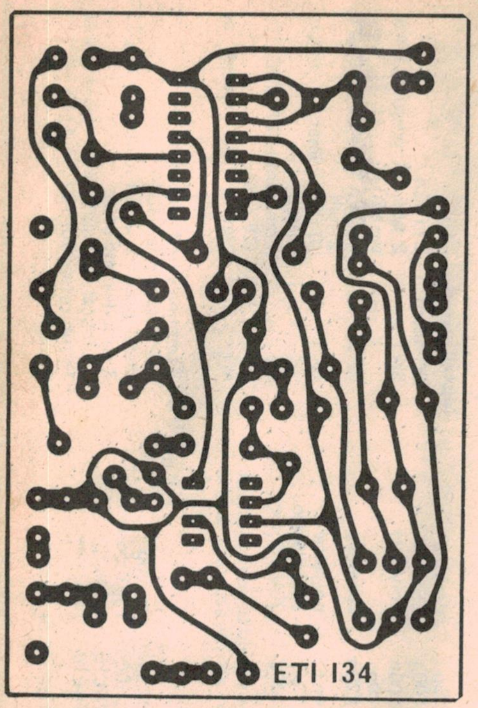


Fig. 4. Printed circuit layout.
Full size 90 x 60 mm.

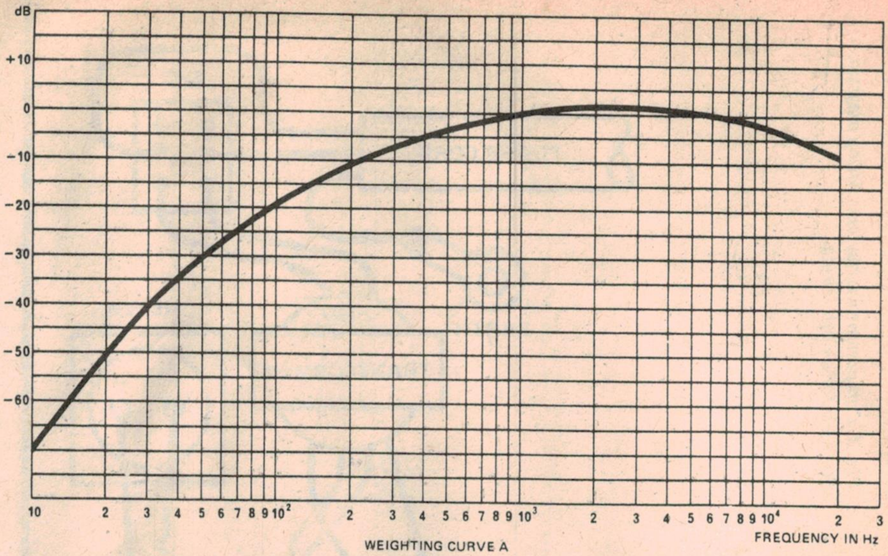


Fig. 6. The response in the " A " weight position.

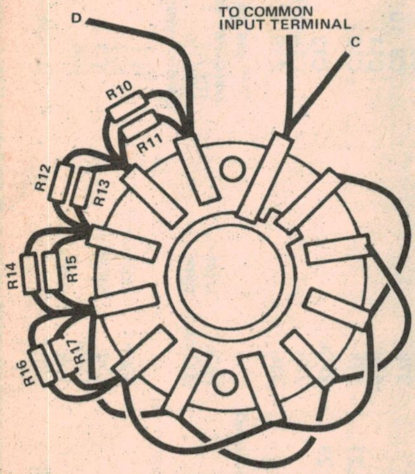


Fig. 5. Connection of the range switch drawn in the 30 V position.

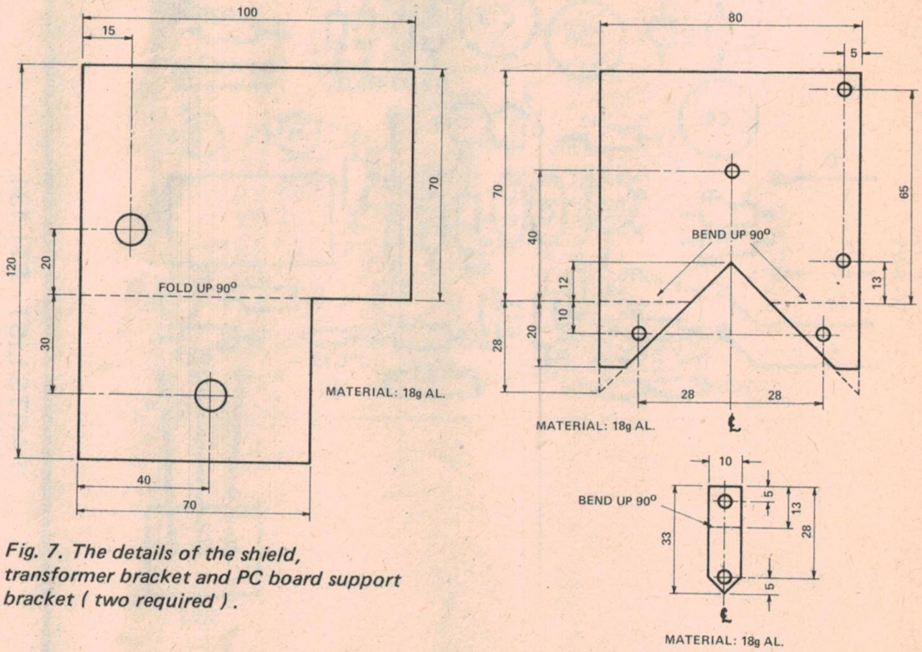
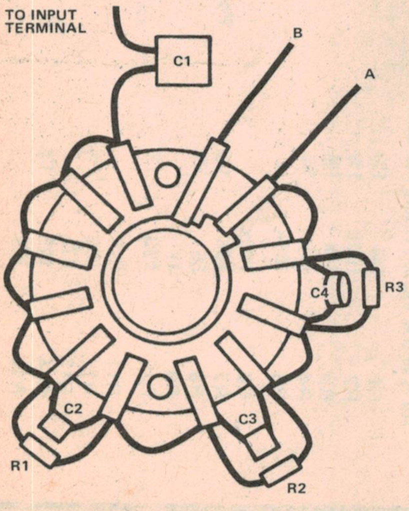
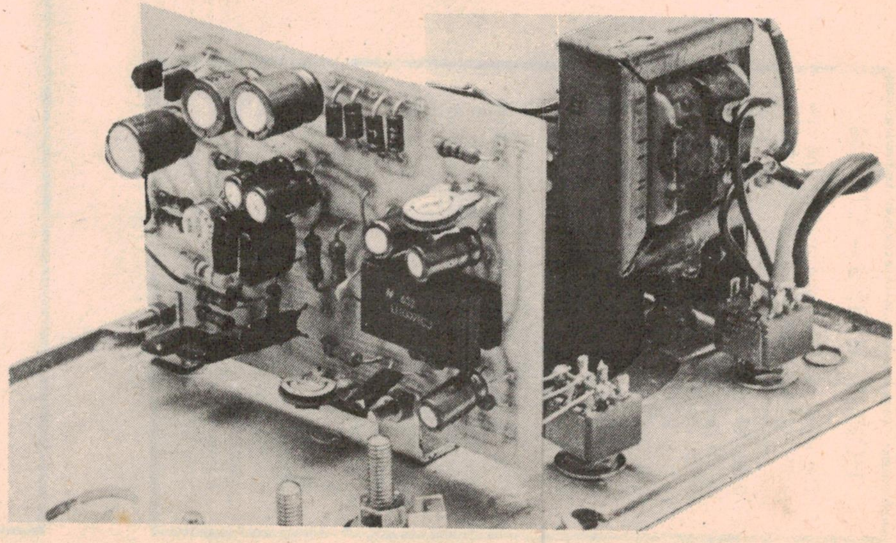
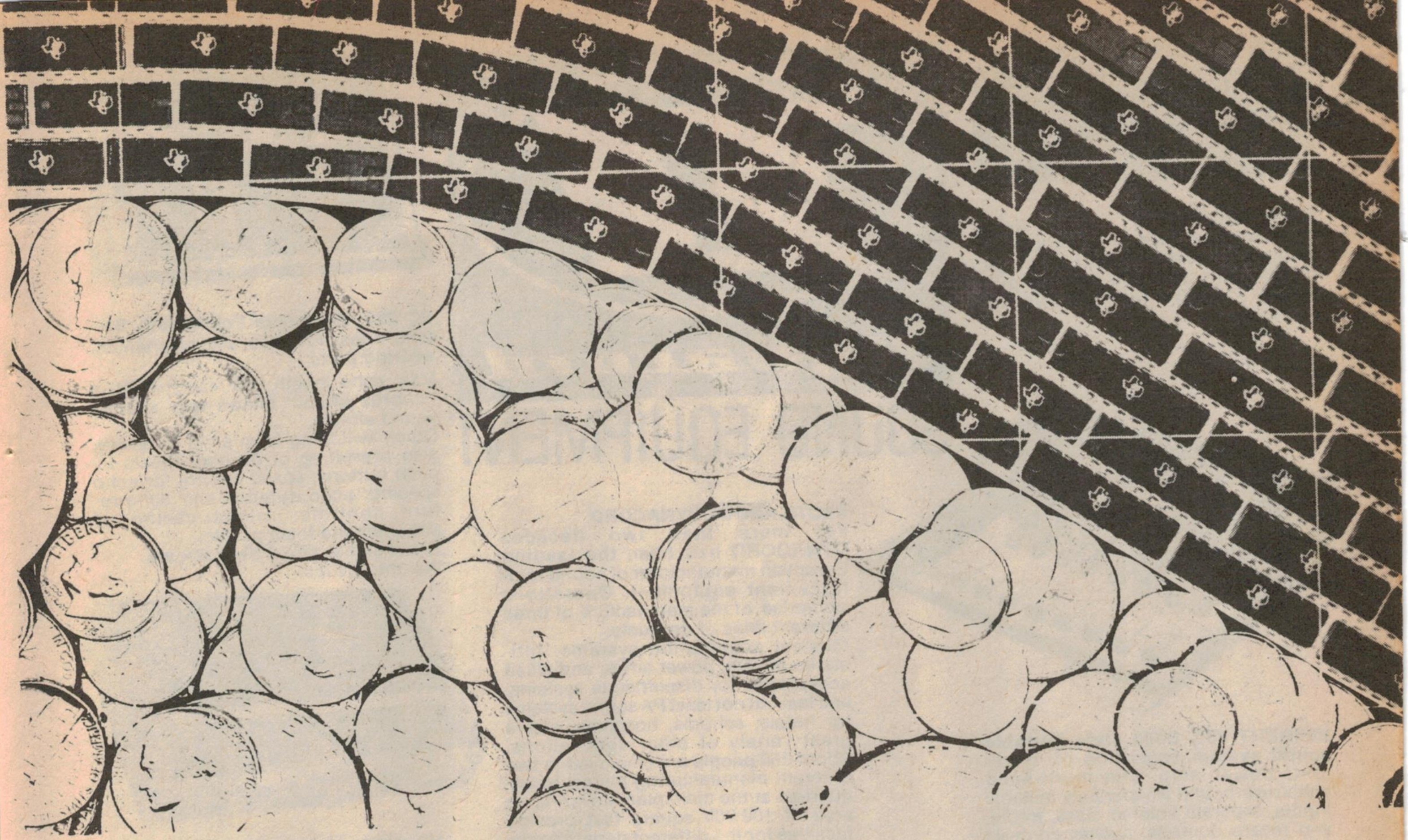
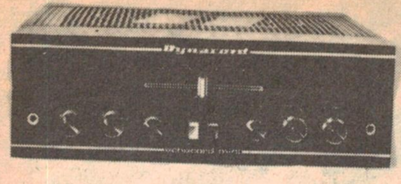


Fig. 7. The details of the shield, transformer bracket and PC board support bracket (two required).





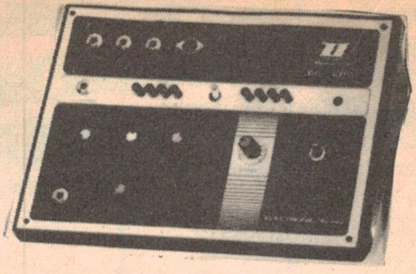




ECHOCORD-MINI, echo/ reverberation unit with endless tape system and sliding sound head: two inputs, tone controls, two outputs; weight: 15½lbs; dimensions: 15¼ x 5½ x 10½ ins.

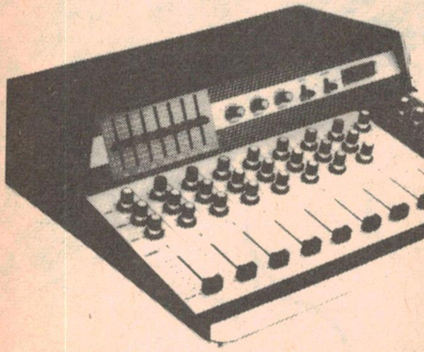
Dynacord

SOUND EQUIPMENT



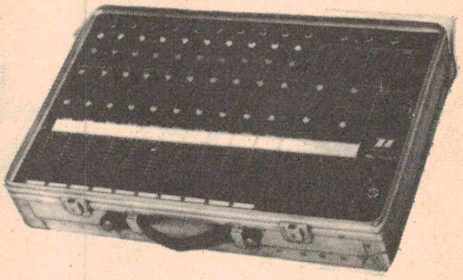
EC 280, Electronic Ech/Reverb System, does not have any mechanical wearing parts.

Max. echo length 280 msec.; built in "chorus effect" allows very special sound effects.
Quick switching from echo to reverb, also presetting of desired effects by push buttons; speed control for echo spacing; echo duration and echo return controls; robust casing of polyurethane foam plastic.
Dimensions: 12¾ x 3¼ x 9¼ ins
Weight: 6½ lbs.



EMINENT 200, Solid state portable sound system consisting of: mixer unit, power amp. and multi-head echo/reverb. unit 8 separately mixable inputs, separate volume, bass, treble, and reverb controls, master controls for volume and echo return; 7-stage equalizer; controls for echo tone and duration, echo/reverb. switch for pre-set reverberation; V.U. meter switchable for power amp. and reverb. output:

FACTS ABOUT DYNACORD
For more than two decades DYNACORD had been the leading European manufacturer of sound reinforcement equipment. Operations comprise of the manufacture of three different lines of products:
Musical amplication systems: hifi-stereo mixers, power amps, and allied accessories for discotheque systems; and last but not least PA sound systems for hotels, schools, hospitals, and a great variety of other applications. About 350 people are employed in two different manufacturing plants. Headquarters at the main plant covering an area of 100,000 square feet provide facilities for the different departments, such as: home sales, export division, buying, accounting, electronic data processing, stocks, service, administration, etc.
Above all there is the research and development department employing 30 graduated engineers and technicians, some of them having a thorough musical experience of their own. They also have an experience inthe field of long standing and apply latest and highly advanced technologies. Almost 50 percent of the total production are being exported to over 100 different countries throughout the world.



MC 1030, 10-Channel Mixer for P.A. systems, housed in aluminum flight case, 10 unbalanced microphone inputs, each with bass, treble, monitor, panorama, volume, and echo control; 3 output jacks with seperate controls left/right, and monitor; outputs left/right with separate bass and treble controls; one echo return control; two illuminated VU meters. Connectors for tape deck, echo, and docking systems for extensions or sub-mixers.
Dimensions: 22 x 7 x 15 ins
Weight: 14¼ lbs.

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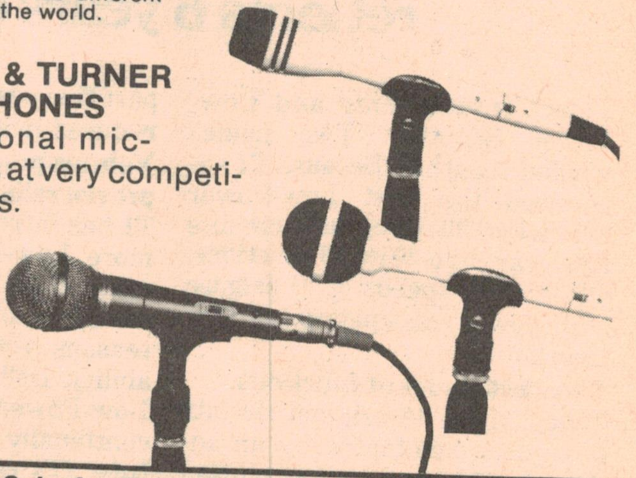

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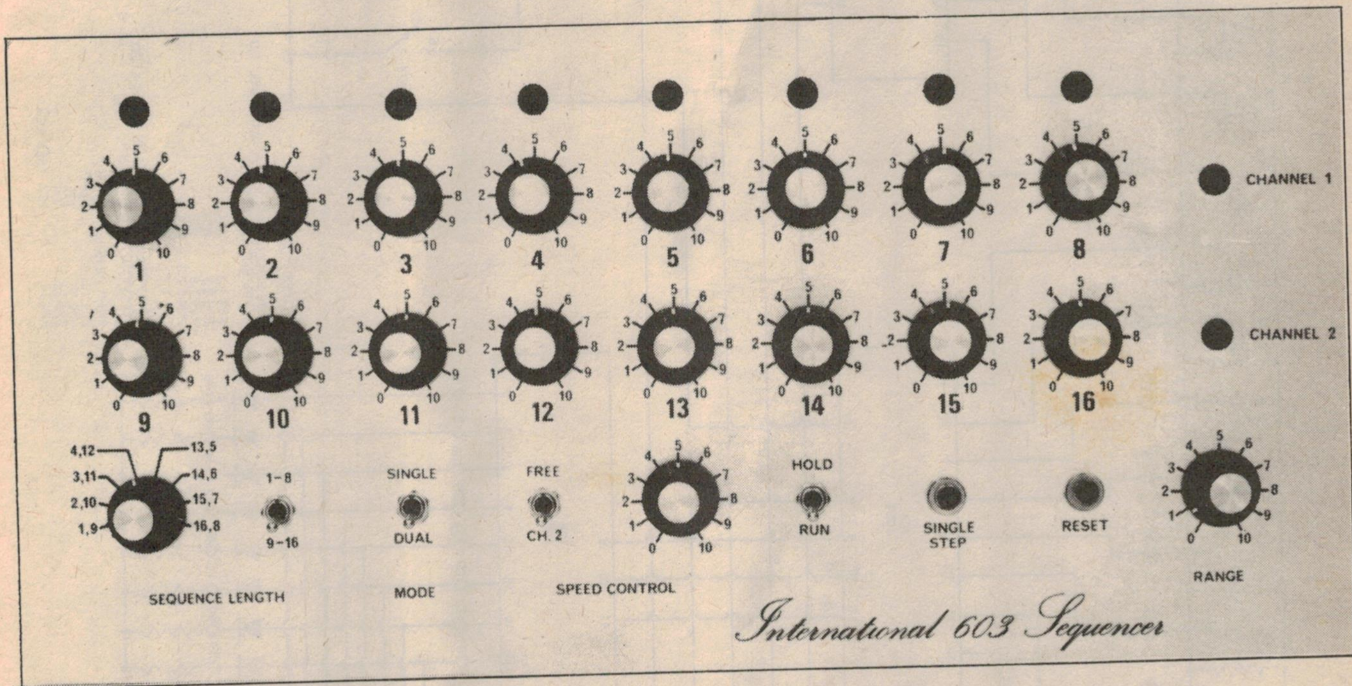
SEQUENCER



ONE OF THE accessories most requested for use with our synthesizer is a sequencer, which allows a rythm to be played using spare VCO's and envelope generators, etc., in the synthesizer while playing the melody with the keyboard.

This unit is capable of replaying up to 16 individual notes at a regular beat or up to eight steps where the beat is variable as well as the pitch. If a regular beat is used, two separate channels are available, provided the length is limited to eight notes or less.

SPECIFICATION – ETI 603	
Number of steps	2 – 16 single output 2 – 8 dual output
Output voltage	0 – 5 Volts
Speed	10 ms – 1 s per step
Output impedance	<1 Ohm
Load resistance	>500 Ohms
Trigger pulse	2 ms negative pulse
Power supply	8 – 15 V dc

Design Features

When initially looking at this unit we had to decide between two different approaches. The first, which is presented here, is to use a heap of potentiometers on which the individual voltages are manually set up and a large multiplexer to select the potentiometers sequentially.

This system is economical up to about sixteen steps. Beyond this, the cost of the hardware, i.e. potentiometers, knobs, panel space, etc., is far more than the cost of the electronics involved.

In the second system, which we may publish at a later date, the tune is entered 'live' through the keyboard and the individual notes, the key depression times, and the intervals between notes are stored in a memory. Up to 256 notes or more could be stored in this way and then replayed as a rythm (or melody!).

This system is obviously much more flexible but it is more expensive and complex if a short sequence is all that is required. However, cost does not rise much for longer lengths.

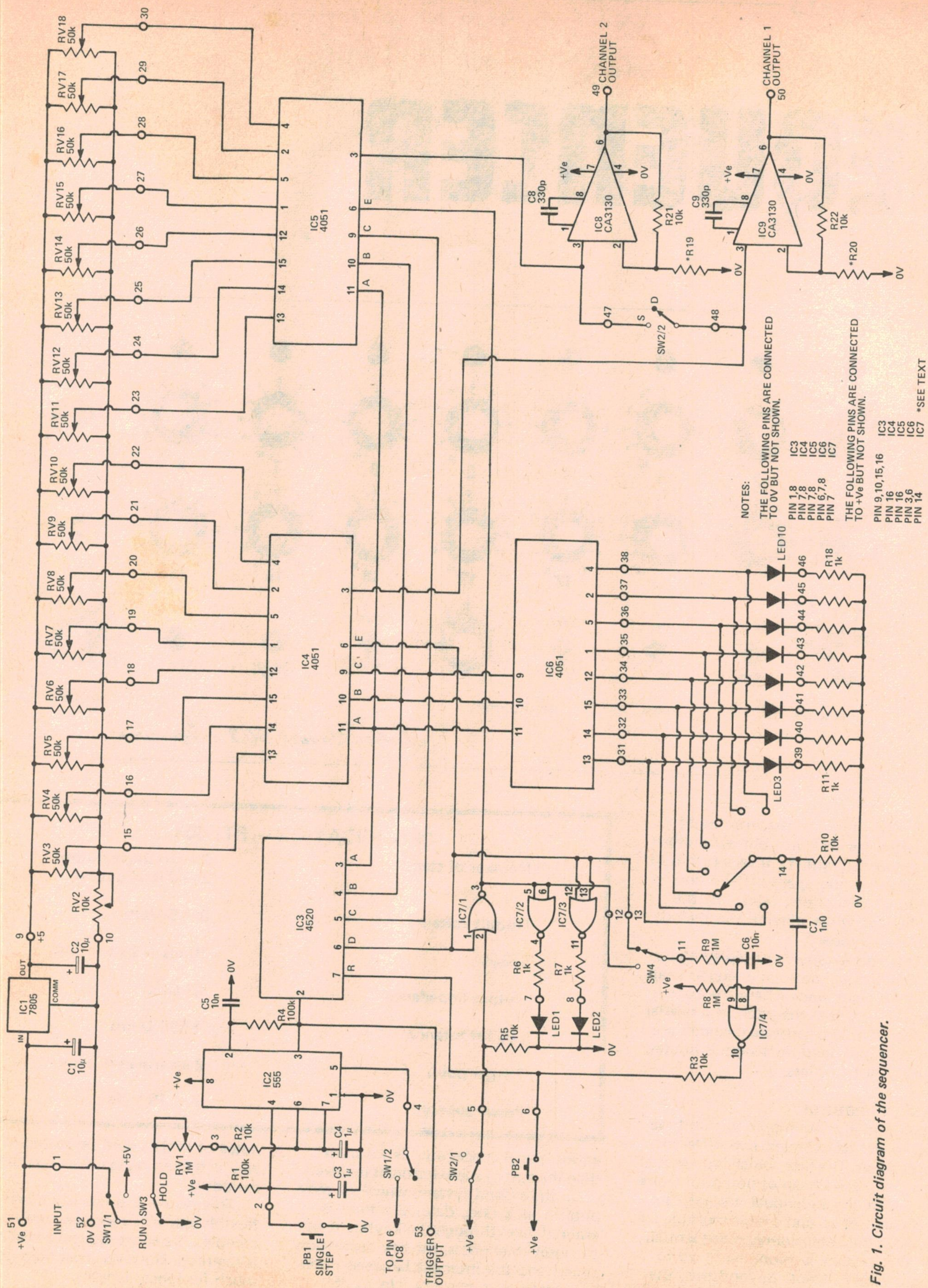


Fig. 1. Circuit diagram of the sequencer.

HOW IT WORKS – ETI 603

The sweep time of the sequencer is controlled by IC2 which is a 555 timer. It clocks IC3, a four-bit binary counter, which gives the 16 steps required. The output however is in four-bit binary form.

The individual levels in the sequence are set on the potentiometers RV3 to RV18 which have a fixed supply voltage across them. One side is at +5 V as set by IC1 and the other side is variable from 0V to about 3.8 V by the range control RV2. This reduces the range over which the synthesizer VCO can be varied, making set-up easier.

These 16 output voltages are connected to the inputs of IC4 and IC5 which are eight-input analogue multiplexers, the selected input depending on the binary code presented to the control inputs. The enable line is used as a control line to allow full 16 input operation. The outputs from IC4 and IC5 both are buffered by IC8 and IC9 to prevent loading the potentiometers.

In the single mode the multiplexers are selected alternately and their outputs are connected so that both buffers have identical outputs. In the dual mode both multiplexers are active, the connection between the outputs is open and the buffer IC9 corresponds to the output of IC4 (RV3 to RV10) and IC8 to that of IC5 (RV11 to RV18). In this mode the sequence is only eight steps long.

Control of sequence length and the position indicator LED's is done by IC6 and IC7. IC6 decodes the lower three bits of the binary code and drives the eight LED's indicating which column is active. The upper bit is inverted by IC7/1 and this output plus the normal output are buffered by IC7/2 and IC7/3 which drive LED's 1 and 2 which are the row indicators.

The output of IC6 is also connected to SW5 which is the sequence length selector. When the sequencer is on the length selected, the voltage on R9 is near the supply rail. When the next step occurs, this voltage falls to zero and C7 connects this pulse onto one input of IC7/4, which resets IC3 back to the start of the sequence, (provided the other input is on zero).

The second input to IC7/4 determines the row and is selected by SW4. The resistor R8 and capacitor C6 provide a slight delay to give correct operation when lengths of 8 or 16 notes are selected.

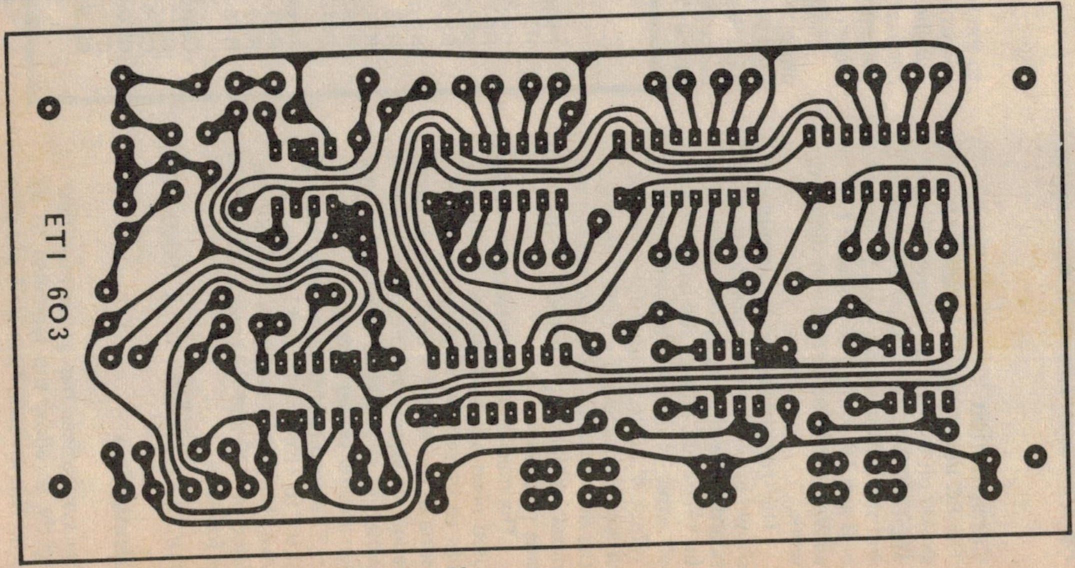


Fig. 2. Printed circuit layout. Full size 140 x 70 mm.

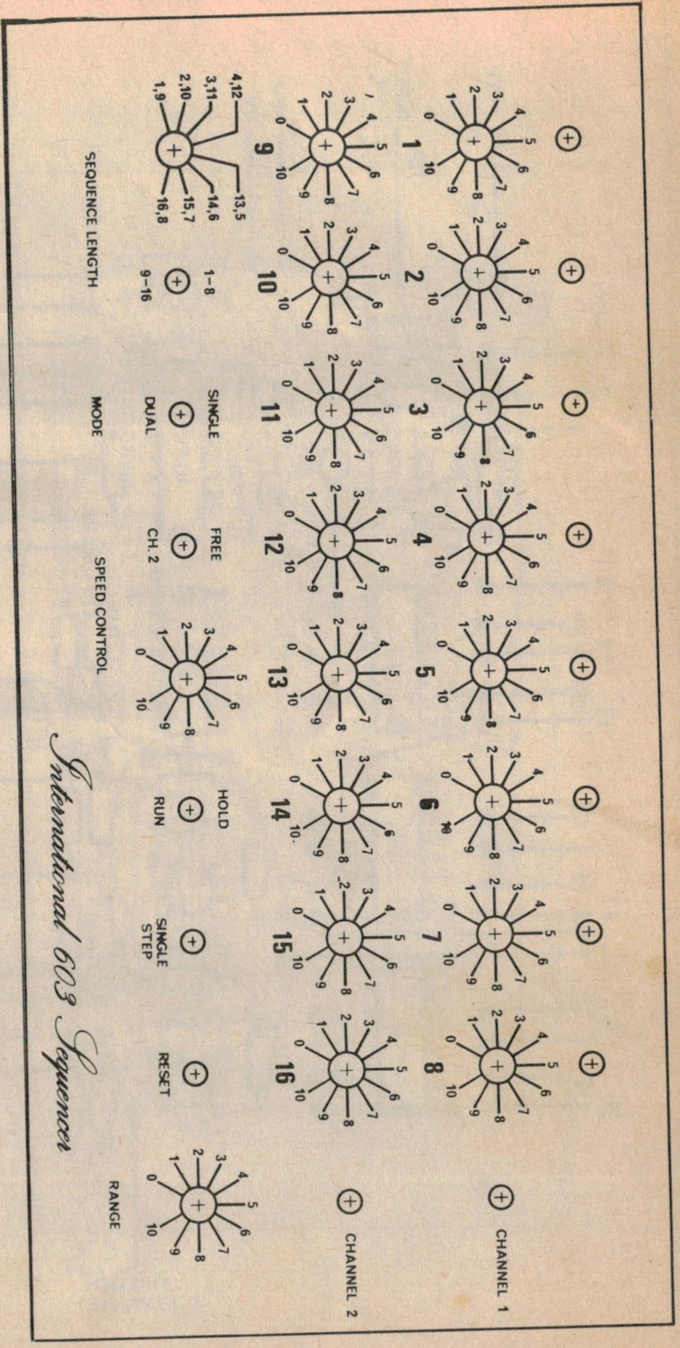


Fig. 3. Front panel artwork. See Fig. 8 for dimensions.

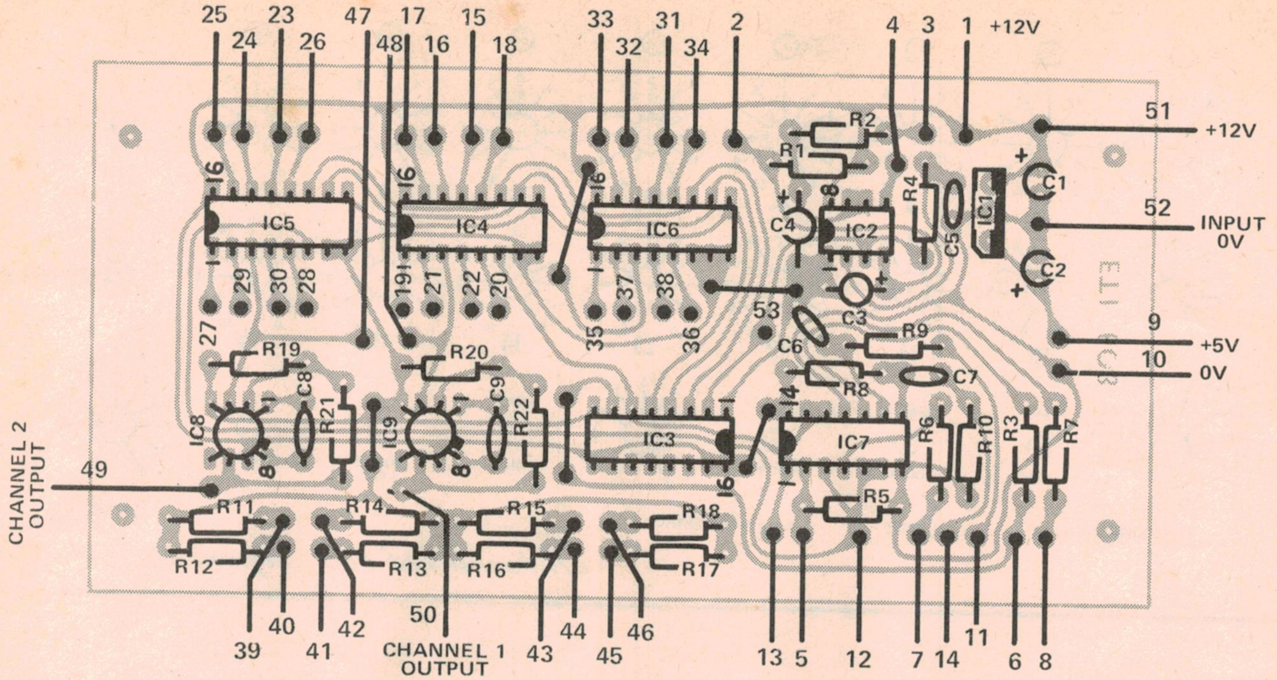


Fig. 4. Component overlay of the sequencer.

Construction

The PC board should be assembled as shown on the overlay diagram (Fig. 4). The CMOS IC's should be installed last and the power supply pins (7 and 14 or 8 and 16) should be soldered first to allow the internal protection diodes to work.

The front panel can be assembled as shown in Fig.5 and interwired to the PC board using the numbers on the wires for reference. Due to the large number of wires it is recommended that 'rainbow' cable be used for neatness. When connecting the LED's note that the shorter lead or the lead nearest the notch or flat on the body is the negative side (cathode).

The mechanical construction we have used need not be followed if the unit has to fit into an existing space and none of the wiring is critical as regards length or layout. We didn't use a power switch as the module was used on the synthesizer power supply.

The output of the unit is in the range of 0V to +5V if R19 and R20 are not used. If a higher voltage is required the value of R19 and R20 can be calculated as follows,

$$R19,20 = \left(\frac{V\ max.}{5} - 1\right) \times 10000 \text{ ohms}$$

Connection

The synthesizer has to be modified slightly to allow the sequence to be used. This involves fitting a 5 pin plug to the rear (0V, +14 V, 2 outputs and trigger) and also three single pole toggle switches (or a 3 pole toggle) to disconnect the external input module from the patch board. The diagram for this is shown below.

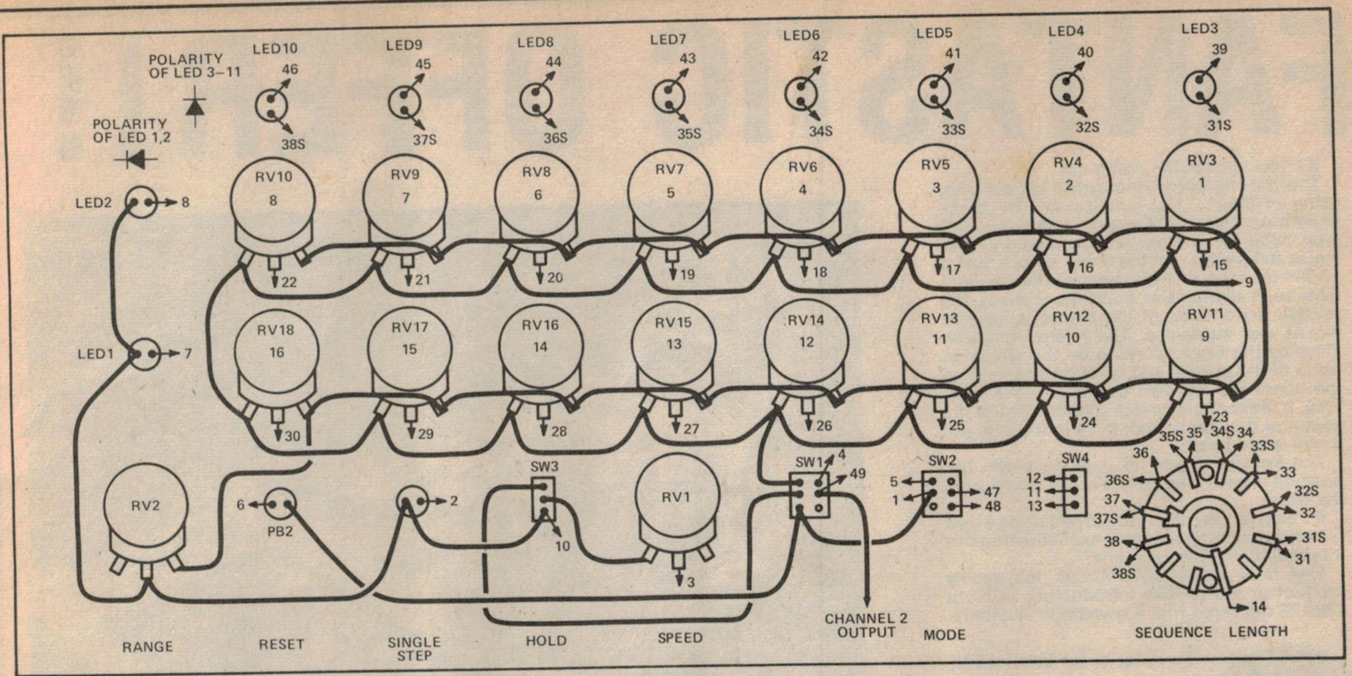
These modifications are for the 4600 units; for while the sequencer can be used with the 3600 the number of spare modules limits its usefulness. One of the outputs could, however, be connected to the "off" position of the oscillators but the trigger pulse is not the correct level to operate the envelope. This module would however be tied up with the keyboard.

An alternative solution would be to build an extra oscillator and perhaps an envelope generator into the sequencer case. This would then form the free-standing unit which could be used with any synthesizer or even electronic organs.

PARTS LIST — ETI 603

Resistors all ½ W 5%	
R1	100k
R2,3	10k
R4	100k
R5	10k
R6,7	1k
R8,9	1M
R10	10k
R11—R18	1k
R19,20	see text
R21,22	10k
Potentiometers	
RV1	1M lin rotary
RV2	10k lin rotary
RV3 — RV18	50k lin rotary
Capacitors	
C1, 2	10μ 16V electro
C3, 4	1μ0 16V electro
C5,6	10n polyester
C7	1n0 polyester
C8, 9	330p ceramic

Semiconductors	
IC1	78L05 or 7805 regulator
IC2	555 timer
IC3	4520 dual binary counter
IC4 — IC6	4051 8-bit data selector
IC7	4001 quad 2-input NOR
IC8, 9	CA3130 op-amp
LED1 — LED10	Red LED with mounting clip
Miscellaneous	
PC board	ETI 603
SW1, 2	DPDT toggle
SW3, 4	SPDT toggle
SW5	single pole, 8 or 11 position
PB1, 2	single make pushbuttons
Front panel to Fig. 8	
Bracket to Fig. 7	
19 Knobs	



NOTES: WIRES 31S TO 38S GO BETWEEN

Fig. 5. Wiring of the front panel.

Fig. 6. Interconnections needed to operate the sequencer with the 4600 synthesizer.

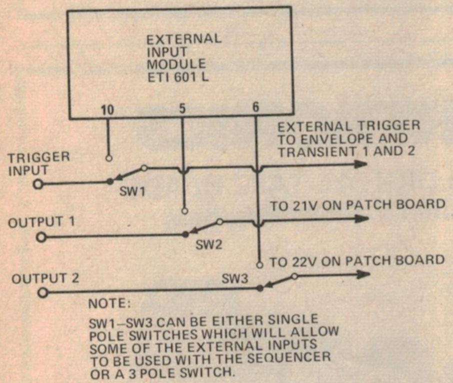


Fig. 7. Details of the small bracket which supports the PC board.

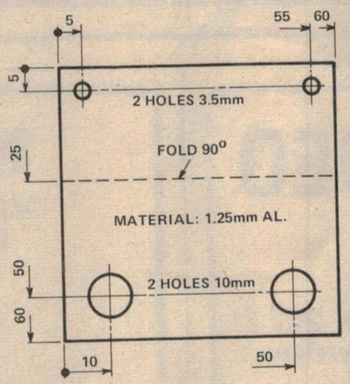
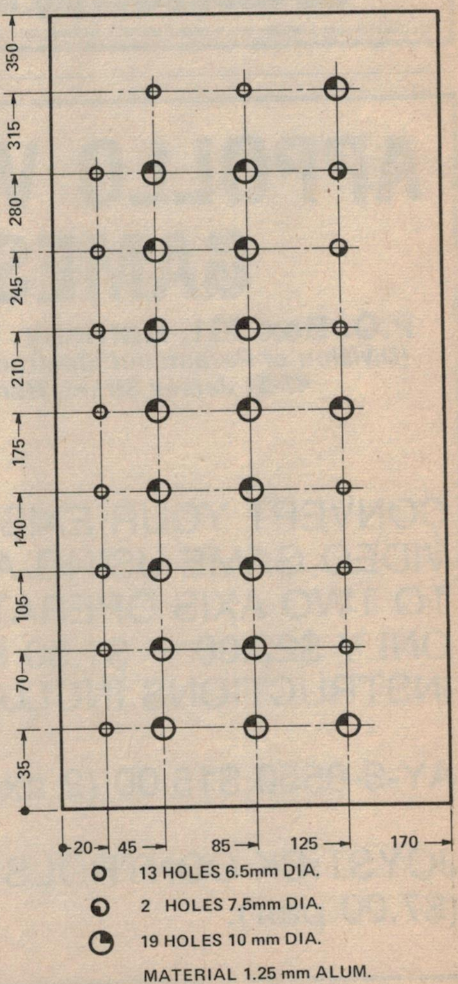
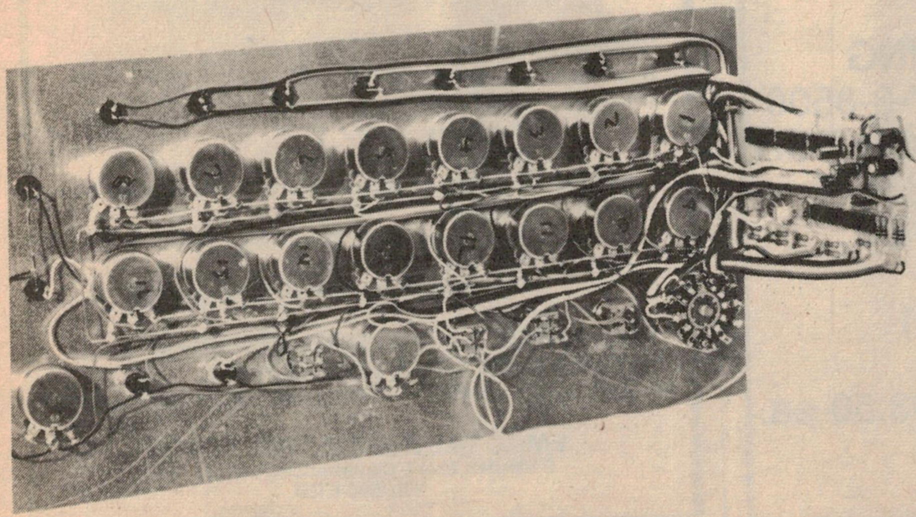


Fig. 8. Details of the front panel metalwork.





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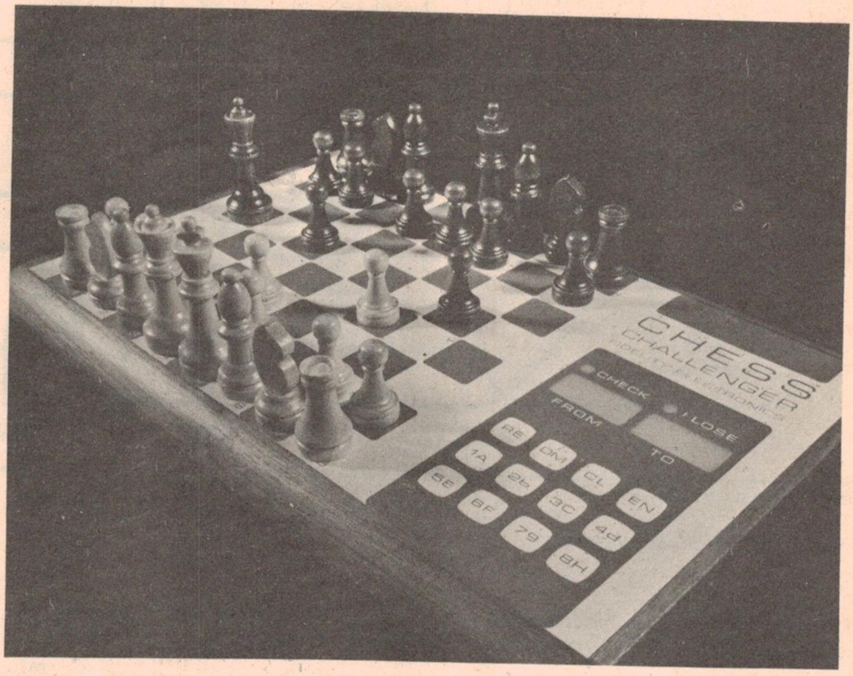

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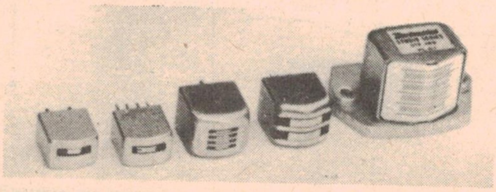

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HOUSE ALARM

Here's what you need to know to protect your home or business against forcible entry — with particular emphasis on installing the ETI 582 alarm.

NEARLY 30% of all burglaries are committed by thieves entering via unlocked doors or windows. A further 24.4% are committed via forced door locks, and about the same percentage via forced windows.

Thus nearly four out of five potential breakins can be avoided by installing adequate door and window locking mechanisms.

Use 'deadlatch' locks on all external doors. These locks can only be opened with a key — even from inside — so even if a thief enters via a window he can't remove any large items (such as colour TVs). Few thieves will risk being seen passing items through a window.

Do have the locks fitted by an experienced locksmith unless you have experience in this field — and don't fall for door-to-door lock salesmen — it's not unknown for them to retain a duplicate key!

Consult a specialist security company about window locking devices. Innumerable types are available for metal, wood framed and sash windows. A burglar might break the glass but few risk climbing through a window frame with broken glass in it.

The precautions outlined above will reduce your chances of being burgled by about 80% — the remaining 20% can be reduced to virtually zero by installing a good burglar alarm. The emphasis must be on the word 'good'. A poor system is worse than none at all for it may go off erratically or not at all. (Over 97% of all burglar alarm warnings are false.)

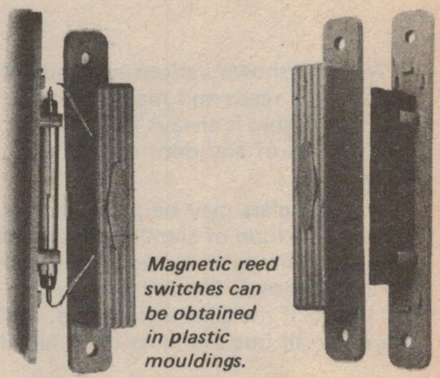
Sensors

For most premises, it is necessary to install sensors to protect front and rear doors, garage entrances, windows, large ventilators and skylights.

A few forcible entries are made *through* the walls or roof, and very occasionally via the floor. Although rare, such forced entries may be guarded against by placing sensors in a strategic passage or area through which an intruder will pass.

The simplest and most reliable switching device for alarm installations is the magnetic reed switch. This consists of a pair of ferromagnetic contacts in a small hermetically sealed glass enclosure. The switch reeds are cantilevered from the ends of the glass tube and overlap slightly at the centre, with a small air gap between them.

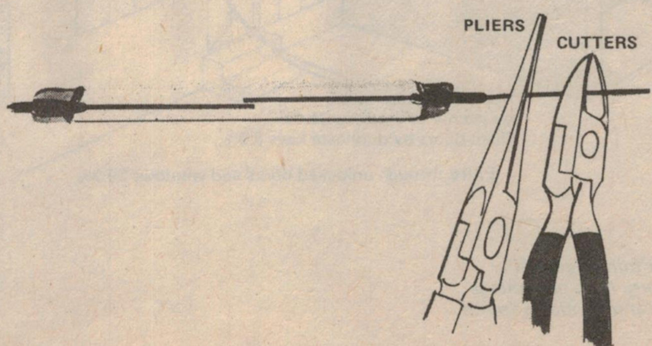
When a magnet is brought near the reed switch, the attracting forces increase and overcome the stiffness of the reeds, bringing them into contact with each other. When the magnet is removed, the contacts reopen. The relative distance for pull-in is always less than for drop-out. This is a valuable feature for small movements of doors and windows will not cause false alarms.



Magnetic reed switches can be obtained in plastic mouldings.

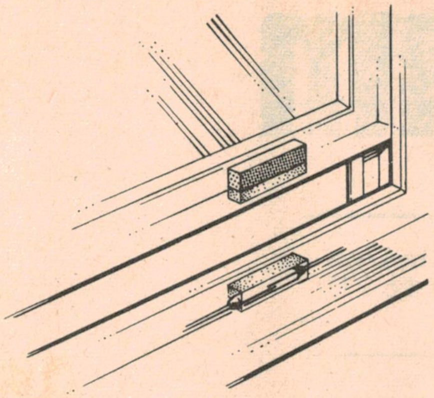
Reed switches purchased for alarm installations must be of a type specifically intended for the purpose — standard reed switches are not suitable.

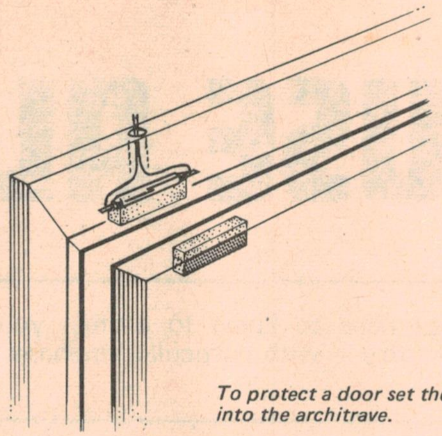
Many professional security companies install reed switches and magnets encased in plastic mouldings. Whilst these mouldings are neat and simple to fit, it is better to conceal both reeds and magnets within the framework of the doors and windows.



Care must be taken if the reed switch connecting leads needs shortening. Hold wire tightly with pliers (as shown) to prevent breaking the glass seal.

Set the reed switch into the window frame and the magnet in to the moving part.





To protect a door set the reed switch into the architrave.

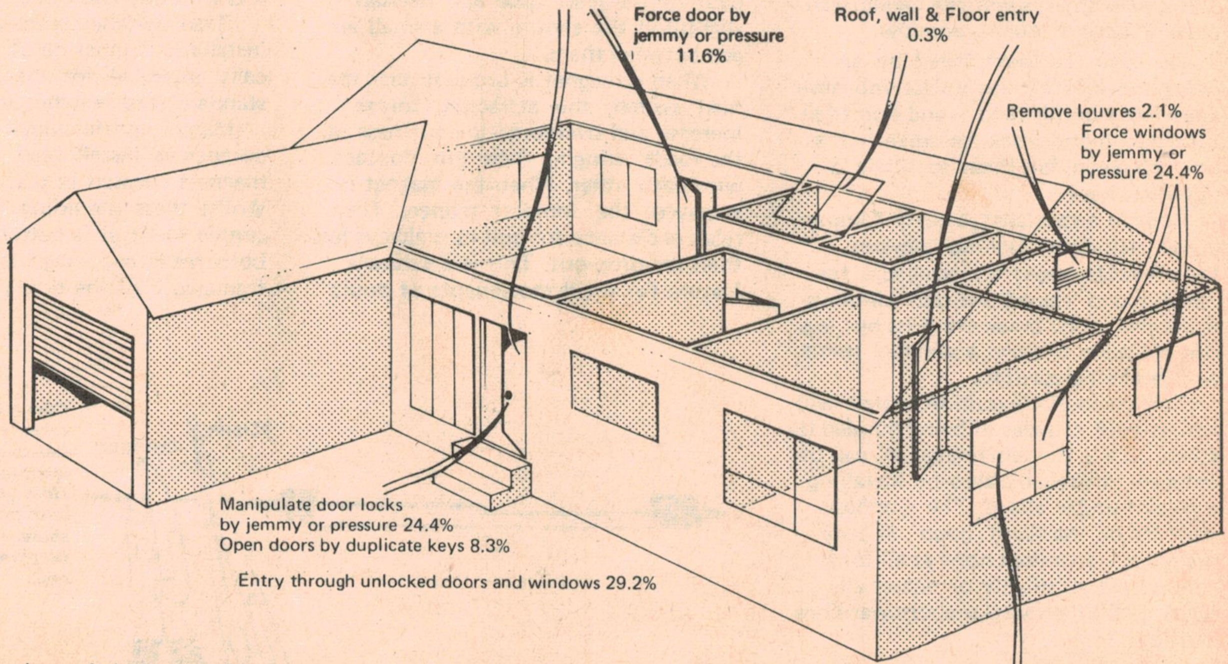
We have shown various methods of locating the reeds and magnets (note that the magnet is always fixed to the moving part of any door or window frame).

Window glass may be protected by glueing on a loop of aluminium foil tape (a self-adhesive type is made specifically for this purpose). The foil is quite thin and breaks if the glass is fractured. Foil will deter all but the most determined burglar. After all why risk being caught when next door doesn't seem to be alarmed?

Vibration sensors may be used to protect large areas of glass, they're effective but prone to false triggering during thunderstorms. Another window protector is a device which listens for the sound of breaking glass! This has an effective range of about five metres on axis and contains circuitry for filtering out false signals.

Many other types of intruder sensing devices can also be included in the system. Pressure mats for example, can be placed under carpets in strategic passageways — or even under the doormat. The mats contain a large number of normally open contacts, some of which will close when the mat is trodden on.

Infra-red beams can be installed if



This sketch shows how criminals generally enter a house. Note the very high percentage of entries made via doors and windows found unlocked.

required. These and other commercially available intruder detectors use a change-over relay output stage. The intruder alarm itself should be reasonably accessible to people entering and leaving the premises via the 'silent entry' door, but well-hidden from the sight of an intruder.

The intruder alarm output stage is a relay which latches when an alarm signal is received.

For household use, a good-quality 12 volt alarm bell will be adequate. Being mechanically resonant, bells have a very high conversion efficiency of electrical to acoustical energy; in fact, the average 12 volt bell draws less than 500 milliamps and can be heard several hundred feet away.

Good sirens can be heard well over half-a-mile away, but they draw a lot of power and also cost more than a good bell. Small, cheap sirens cannot be recommended.

If at all possible, householders should make mutual arrangements with neighbours to contact the police if the alarm is heard. Similar arrangements should also be made so that neighbours can switch off the alarm after the police arrive.

The alarm bell should be mounted unobtrusively, high up in an inaccessible place. The leads to the bell should be run in 40/0076 (to reduce voltage drop) and concealed from view. We strongly recommend that a separate 12 volt battery be used.

Notes:

One approach is to connect the alarm output relay to switch on a number of floodlights. It will be necessary to drive a heavy-duty contactor to carry the lighting current. Intense lighting will dissuade an intruder as thoroughly as an audible warning, and it's less traumatic for the awakened householder. Where business premises are concerned, the bell should also be retained.

The Alarm Unit

An extremely effective electronic alarm unit is the ETI Project 582 described in Electronics Today International last month. (Photostat copies may be obtained from Electronics Today — price is $1.50). This unit enables each sensor or group of sensors to be connected to a separate sensing circuit. If any one sensor is triggered the alarm will be activated for a period of twelve minutes. At the end of that time triggering of any other sensor will once again initiate the alarm sequence.

The ETI 582's main alarm circuits are triggered by an intruder 'breaking' a normally-closed loop: thus if a switch is opened or the wiring is cut the alarm will be triggered.

The 582 alarm has seven main external 'normally-closed' circuit, plus a 'silent-entry' circuit but it is of course possible to connect two or more alarm switches in series for each main external circuit. If so doing do ensure that any such series-connected alarm switches are grouped together.

The silent-entry circuit shown as A1 in the project article is included so that the occupier can leave and enter the premises without activating the alarm. The silent-entry circuit is wired in the same way as the other external circuits.

The 582 system has provision for connecting a number of internal circuits. These may be actuated by 'normally closed' sensors — in which case the sensors should be connected to circuits B1 — Bn, or by 'normally open' sensors which should be connected to the normally open input point (A9).

It may well be worth considering installing a series of emergency push buttons. Such switches should be mounted on the architraves of the front and rear doors or in a readily accessible position near the doors. They enable the occupant to set off the alarm if a caller forces his way into the house when the door is opened. Although this is not a common event, emergency switches provide elderly or timid people with a feeling of security.

Use good quality bell pushes for these circuits and connect them to the A9 inputs on the circuit board.

Fire Alarms

Fire sensors may be wired across the A9 input. The actual fire sensors should be mounted in the ceilings of rooms in which there is a fire hazard — kitchen, living room, rooms with electrical or heating appliances, or where people smoke (don't forget the bedroom if you've a habit of smoking in bed!). Sensors should also be installed in the roof of the garage especially if this is attached to the house — the laundry, workshop etc.

The installation of an intruder alarm should only be *part* of a co-ordinated campaign to dissuade burglars. There are a number of simple precautions that should also be used. Details of these are contained in an excellent series of leaflets obtainable from the Crime Prevention Bureau of your local police headquarters.

ETI data sheet

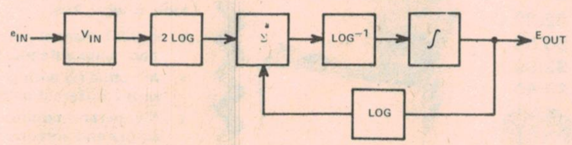
LH0091 true rms to dc converter

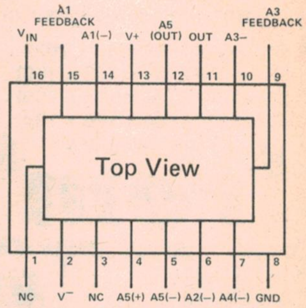
The LH0091 RMS to DC converter generates a DC output equal to the RMS value of any input using the transfer function:

$$E_{0(DC)} = \sqrt{\frac{1}{T}\int_0^T E_{IN}^2(t)\,dt}$$

The device provides RMS conversion to an accuracy of 0.1% of reading using the external trim procedure. It is possible to trim for maximum accuracy (0.5 mV ± 0.05% typical) for decade ranges e.g. 10 mV to 100 mV, 0.7 V to 7 V, etc. A block diagram of the device is shown in Fig. 1. It also contains an uncommitted op-amp (A5), which is similar to the 741 type.

Block and connection diagrams





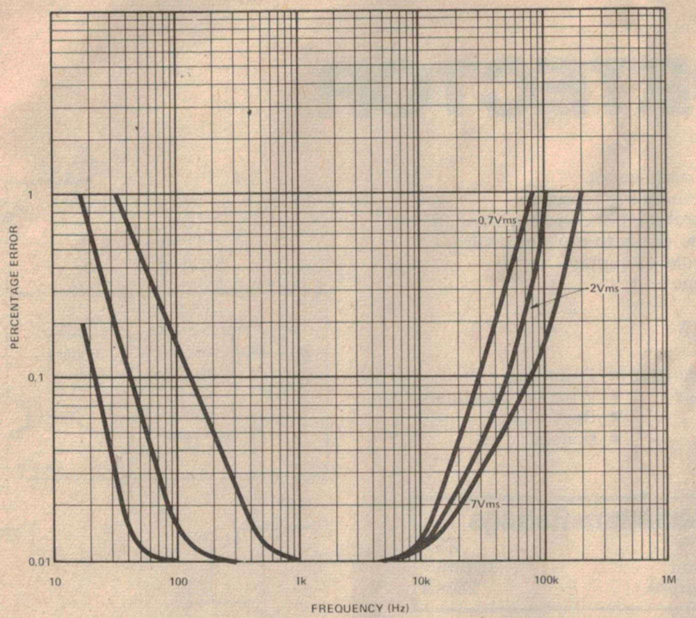
Dual-In-Line Package

Absolute maximum ratings

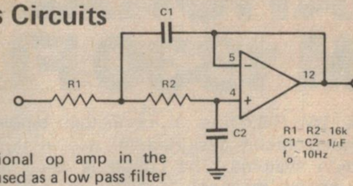
Supply Voltage	∓22V	
Input Voltage	∓15V peak	
Output Short Circuit Duration	Continuous	
Operating Temperature Range	T_{MIN} -55°C	T_{MAX} 125°C

Electrical characteristics at Vs =∓25° C, unless otherwise specified.

PARAMETER	CONDITION	TYP
ACCURACY		
Total Unadjusted Error Total Adjusted Error	50mVrms≤ Vin≤ 7Vrms	20mV ∓0.5% 0.5 mV ∓ 0.05%
AC PERFORMANCE		
Bandwidth (3dB)	input=7Vrms, Sinewave input=0.7Vrms, Sinewave input=0.1Vrms, Sinewave	2MHz 1.5MHz 0.8MHz
Crest Factor	Rated Adjusted Accuracy Using the High Crest Factor Circuit	10
INPUT CHARACTERISTICS		
Input Voltage Range Input Impedance	For Rated Performance	∓0.05:∓11V peak 5kΩ
OUTPUT CHARACTERISTICS		
Rated Output Voltage Output Short Circuit Current Output Impedance	$R_L \geq 2.k\Omega$	10V 22 mA 1Ω
POWER SUPPLY REQUIREMENTS		
Operating Range Quiescent Current	V_S = ∓15V	∓5 to ∓20V 14mA

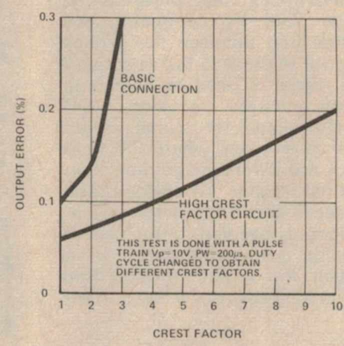


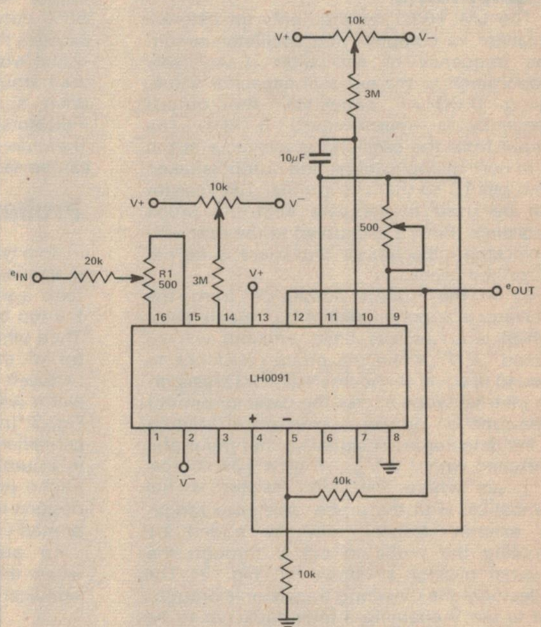
Applications Circuits



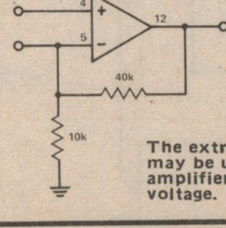
Note: The additional op amp in the LH0091 may be used as a low pass filter as shown.

Circuit for High Crest Factors





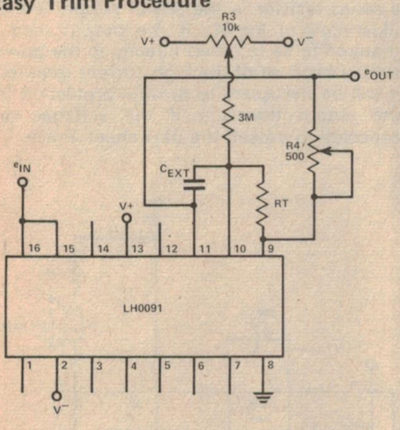
Note: When converting signals with a crest factor ⩽ 2, the LH0091 should be connected as shown. Note that this circuit utilizes a 20k resistor to drop the input current by a factor of five. The frequency response will correspond to a voltage which is 1/5 e_{IN}.



The extra op amp in the LH0091 may be used to build a gain of 5 amplifier to restore the output voltage.

Trim Procedures

Easy Trim Procedure

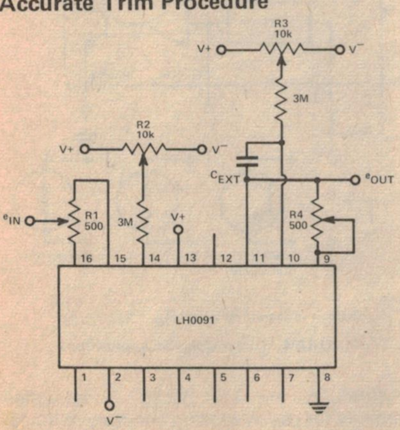


Note: The easy trim procedure is used for ac coupled input signals. It involves two trims and can achieve accuracies of 2 mV offset ∓1% reading.

Procedure:

1. Apply 100 mV rms (sine wave) to input, adjust R3 until the output reads 100 mV_{DC}.
2. Apply 5 V rms (sine wave) to input, adjust R4 until the output reads 5 V_{DC}.
3. Repeat steps 1 and 2 until the desired initial accuracy is achieved.

Accurate Trim Procedure



Note: This procedure will give accuracies of 0.5 mV offset ∓0.05% reading for inputs from 0.05V peak to 10V peak.

Procedure:

1. Apply 50mV_{DC} to the input. Read and record the output.
2. Apply -50mV_{DC} to the input. Use R2 to adjust for an output of the same magnitude as in step 1.
3. Apply 50mV to the input. Use R2 to adjust the output for 50mV.
4. Apply -50mV to input. Use R2 to adjust the output for 50mV.
5. Apply ∓10V alternately to the input. Adjust R1 until the output readings for both polarities are equal (not necessary that they be exactly 10V).
6. Apply 10V to the input. Use R4 to adjust for 10V at the output.
7. Repeat this procedure to obtain the desired accuracy.

ETI data sheet

NATIONAL LM 1830 FLUID DETECTOR

The LM 1830 is a monolithic bipolar integrated circuit designed for use in fluid detection systems. The circuit is ideal for detecting the presence, absence or level of water, or other polar liquids. An AC signal is passed through two probes within the fluid. A detector determines the presence or absence of the fluid by comparing the resistance of the fluid between the probes with the resistance internal to the integrated circuit. An AC signal is used to overcome plating problems incurred by using a DC source. A pin is available for co.necting an external resistance in cases where the fluid impedance is of a different magnitude than that of the internal resistor. When the probe resistance increases above the preset value, the oscillator signal is coupled to the base of the open-collector output transistor. In a typical application, the output could be used to drive a LED, loud speaker or a low current relay.

Applications

The LM 1830 requires only an external capacitor to complete the oscillator circuit. The frequency of oscillation is inversely proportional to the external capacitor value. Using 0.001 μF capacitor, the output frequency is approximately 6 kHz. The output from the oscillator is available at pin 5. In normal applications, the output is taken from pin 13 so that the internal 13k resistor can be used to compare with the probe resistance. Pin 13 is coupled to the probe by a blocking capacitor so that there is no net DC on the probe.

Since the output amplitude from the oscillator is approximately 4 V_{BE}, the detector (which is an emitter base junction) will be turned "ON" when the probe resistance to ground is equal to the internal 13kΩ resistor. An internal diode across the detector emitter base junction provides symmetrical limiting of the detector input signal so that the probe is excited with $\pm 2\ V_{BE}$ from a 13k source. In cases where the 13k resistor is not compatible with the probe resistance range, an external resistor may be added by coupling the probe to pin 5 through the external resistor as shown in Fig. 2. The collector of the detecting transistor is brought out to pin 9 enabling a filter capacitor to be connected so that the output will switch "ON" or "OFF" depending on the probe resistance. If this capacitor is omitted, the output will be switched at approximately 50% duty cycle when the probe resistance exceeds the reference resistance. This can be useful when an audio output is required and the output transistor can be used to directly drive a loud speaker. In addition, LED indicators do not require DC excitation. Therefore, the cost of a capacitor for filtering can be saved.

Dual-In-Line Package

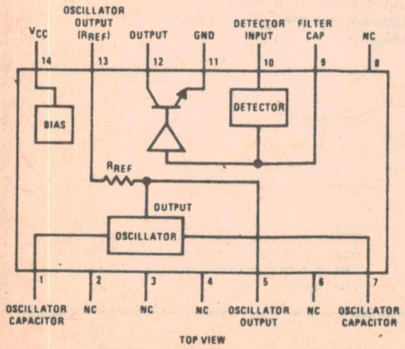


Fig. 1 Pinouts

Features

- Low external parts count
- Wide supply operating range
- One side of probe input can be grounded
- AC coupling to probe to prevent plating
- Internally regulated supply
- AC or DC output

Applications

- Beverage dispensers
- Water softeners
- Irrigation
- Sump pumps
- Aquaria
- Radiators
- Washing machines
- Reservoirs
- Boilers

Absolute Maximum Ratings

Supply Voltage	28V
Power Dissipation	300mW
Output Sink Current	20mA

Probes

In a typical application where the device is employed for sensing low water level in a tank, a simple steel probe may be inserted in the top of the tank with the tank grounded. Then when the water level drops below the tip of the probe, the resistance will rise between the probe and the tank and the alarm will be operated. This is illustrated in Fig. 3. In situations where a non-conductive container is used, the probe may be designed in a number of ways. In some cases a simple phono plug can be employed. Other probe designs include conductive parallel strips on printed circuit boards.

In automotive and other applications where the power source is known to contain significant transient voltages, the internal regulator on the LM 1830 allows protection to be provided by the simple means of using a series resistor in the power supply line as illustrated in Fig 4. If the output load is required to be returned directly to the power supply because of the high current required, it will be necessary to provide protection for the output transistor if the voltages are expected to exceed the data sheet limits.

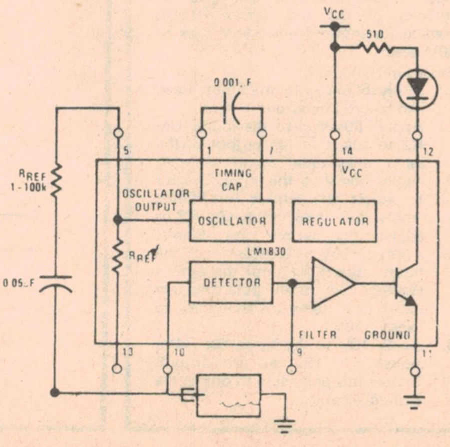


FIGURE 2. Application Using External Reference Resistor

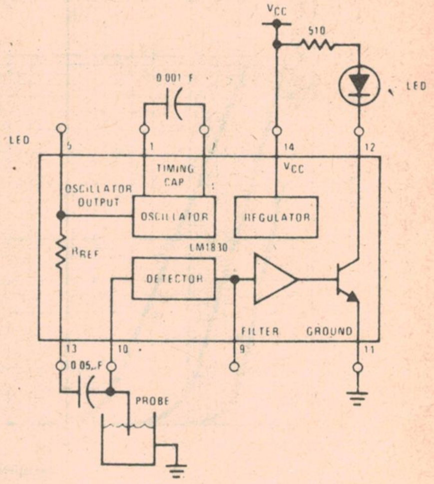
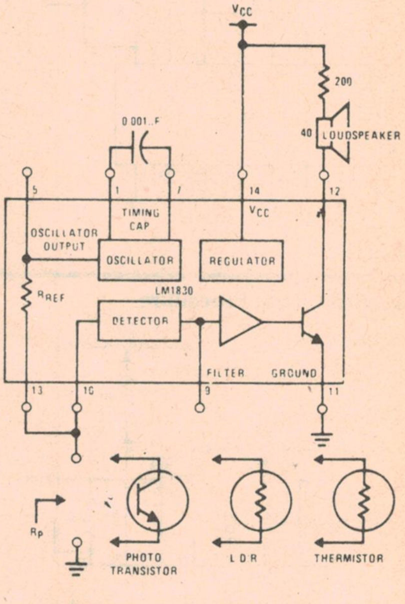


FIGURE 3. Basic Low Level Warning Device



Output is activated when $R_p \gtrsim 1/3\ R_{REF}$

FIGURE 4. Direct Coupled Applications

Although the LM 1830 is designed primarily for use in sensing conductive fluids, it can be used with any variable resistance device, such as light dependent resistor or thermistor or resistor or resistive position transducer.

KITS FOR ETI PROJECTS

We get many enquiries from readers wanting to know where they can get kits for the projects we publish. The list below indicates the suppliers we know about and the kits they do.

Any companies who want to be included in this list should phone LES BELL on 33-4282.

Key to companies:

- **A** Applied Technology Pty. Ltd. of Hornsby, NSW.
- **C** Amateur Communications Advancements, PO Box 57, Rozelle, NSW.
- **D** Dick Smith Pty. Ltd. of Crows Nest, NSW.
- **E** E.D. & E. Sales, Victoria.
- **J** Jaycar Pty. Ltd. of Haymarket, NSW.
- **L** Delsound Pty. Queensland.
- **N** Nebula Electronics Pty. Ltd. of Rushcutters Bay, NSW.
- **O** Appollo Video Games of Hornsby, NSW.
- **P** Pre-Pak Electronics of Croydon, NSW.
- **S** BKX Electronics Supply Service of Kings Cross, NSW.

PROJECT ELECTRONICS

ETI 043	Heads or Tails	A
ETI 044	Two-Tone Doorbell	A
ETI 061	Simple Amplifier	A
ETI 064	Intercom	A
ETI 066	Temperature Alarm	A
ETI 068	LED Dice	A

TEST EQUIPMENT

ETI 101	Logic Power Supply	E
ETI 102	Audio Signal Generator	E,D
ETI 103	Logic Probe	E
ETI 107	Widerange Voltmeter	E
ETI 108	Decade Resistance Box	E
ETI 109	Digital Frequency Meter	E
ETI 111	IC Power Supply	E
ETI 112	Audio Attenuator	E
ETI 113	7-Input Thermocouple Meter	P,E
ETI 116	Impedance Meter	E
ETI 117	Digital Voltmeter	E,A
ETI 118	Simple Frequency Counter	E,A
ETI 119	5 V Switching Regulator supply	E
ETI 120	Logic Probe	L,E
ETI 121	Logic Pulser	L,E
ETI 122	Logic Tester	E
ETI 123	CMOS Tester	E
ETI 124	Tone Burst Generator	E
ETI 128	Audio Millivoltmeter	L,E
ETI 129	RF Signal Generator	L,E
ETI 131	General Purpose power supply	E,N
ETI 132	Power Supply	N

SIMPLE PROJECTS

ETI 206	Metronome	E
ETI 218	Monophonic Organ	E,D
ETI 219	Siren	E
ETI 220	Siren	E
ETI 222	Transistor Tester	E
ETI 232	Courtesy Light Extender	E
ETI 234	Simple Intercom	E
ETI 236	Code Practice Oscillator	E
ETI 239	Breakdown Beacon	E

MOTORISTS' PROJECTS

ETI 301	Vari-Wiper	E
ETI 302	Tacho Dwell	E
ETI 303	Brake-light Warning	E
ETI 309	Battery Charger	P,E
ETI 312	CDI Electronic Ignition	P,E
ETI 313	Car Alarm	E,D

AUDIO PROJECTS

ETI 401	Audio Mixer FET Four Input	E
ETI 403	Guitar Sound Unit	E
ETI 406	One Transistor Receiver	E
ETI 407	Bass A,p	E
ETI 408	Spring Reverb. Unit	E
ETI 410	Super Stereo	E
ETI 413	100 Watt Guitar Amp	P,L,E,J,D
ETI 413	x 200 Watt Bridge Amp	S E
ETI 414	Master Mixer	E,J
ETI 414	Stage Mixer	E
ETI 416	25 Watt Amplifier	E
ETI 417	Amp Overload Indicator	E
ETI 419	Guitar Amp Pre-Amp	P,E,D
ETI 420	Four-channel Amplifier	L,E
ETI 420E	SQ Decoder	E
ETI 422	International Stereo Amp	S L,E,D
ETI 422B	Booster Amp	E
ETI 422	50 Watt Power Module	E
ETI 423	Add-on Decoder Amp	E
ETI 424	Spring Reverberation Unit	S L,E
ETI 425	Integrated Audio System	E
ETI 426	Rumble Filter	E
ETi 427	Graphic Equaliser	S L,E,J
ETI 430	Microphone Line Amp	E
ETI 433	Active Crossover	E,J
ETI 435	Crossover Amp	E,J
ETI 438	Audio Level Meter	L,E
ETI 440	Simple 25 Watt Amp	L,E
ETI 441	Audio Noise Generator	L,E
ETI 443	Compressor-Expander	E.J
ETI 444	Five Watt Stereo	E
ETI 445	Preamp	J,E,D
ETI 446	Audio Limiter	J,E
ETI 447	Phaser	E,J
ETi 449	Balanced Mic Preamp	J
ETI 480	50 W, 100 W Power Amp	A
ETI 480P	Power Supply	A
ETI 482A	Preamp Module	A
ETI 482B	Tone Controller	A
ETI 485	Graphic Equalizer	J

MISCELLANEOUS

ETI 502	Emergency Flasher	E
ETI 503	Burglar Alarm	E
ETI 505	Strobe	L,E,D
ETI 506	Infra-Red Alarm	E
ETI 509	50-Day Timer	E
ETI 512	Photographic Timer	E
ETI 513	Tape Slide/Synchroniser	E
ETI 514	Flash Unit — Sound Operated	E
ETI 515	Flash Unit — Light operated	E
ETI 518	Light Beam Alarm	E
ETI 525	Drill Speed Controller	E
ETI 526	Printimer	E
ETI 527	Touch Control Light Dimmer	E
ETI 528	Home Burglar Alarm	P,E
ETI 529	Electronic Poker Machine	E
ETI 533	Digital Display	L,E,A
ETI 534	Calculator Stopwatch	A,D
ETI 539	Touch Switch	E
ETI 540	Universal Timer	E
ETI 541	Train Controller	E
ETI 543	Double Dice	A
ETI 544	Heartrate Monitor	A

ELECTRONIC MUSIC

ETI 601		
4600	Synthesiser	J
3600	Synthesiser	J
ETI 602	Mini Organ	E,A,D

COMPUTER PROJECTS

ETI 630	Hex Display	A
ETI 631	VDU Keyboard Encoder	A
ETI 632	VDU 1 k x 8 Memory Card	A
ETI 633	VDU Sync Generator	A

RADIO PROJECTS

ETI 701	TV Masthead Amplifier	E,D
ETI 702	Radar Intruder Alarm	D
ETI 703	Antenna Matching Unit	E
ETI 704	Crosshatch/Dot Generator	L,A,D,E
ETI 706	Marker Generator	E
ETI 707	Modern Solid State Converters	C,E
ETI 708	Active Antenna	E
ETI 710	2 metre Booster	C,E
ETI 711B	Single Relay Remote Control	A
ETI 711C	Double Relay Remote Control	A
ETI 711R	Receiver	A
ETI 711AR	Remote Control Transmitter	A
ETI 711DR	Remote Control Decoder	A
ETI 740	FM Tuner	A
ETI 780	Novice Transmitter	E

ELECTRONIC GAMES

ETI 804	Selecta-Game	O,A,D

TTL - standard

7413	DUAL SCHMITT	30¢	4	for	$1.00
7440	DUAL BUFFER	30¢	4	for	$1.00
7442	BCD -10 DECODER	60¢	2	for	$1.00
7445	BCD -10 DRIVER	$1.10	2	for	$2.00
7446	BCD -7 SEG DRIVER	$1.20	2	for	$2.00
7447	BCD -7 SEG DRIVER	$1.10	2	for	$2.00
7453	2-2-2-2 AND OR	30¢	4	for	$1.00
7460	DUAL EXPANDER	30¢	4	for	$1.00
7470	JK FF	30¢	4	for	$1.00
7474	DUAL D FF	60¢	2	for	$1.00
7479	DUAL D FF	60¢	2	for	$1.00
7480	FULL ADDER	60¢	2	for	$1.00
7483	FULL ADDER	90¢	3	for	$2.00
7491	8 BIT SHIFT	60¢	2	for	$1.00
7492	12 COUNTER	60¢	2	for	$1.00
74121	MONOSTABLE	40¢	3	for	$1.00
74125	QUAD TRISTATE	80¢	3	for	$2.00
74141	BCD TO NIXE	$1.20	2	for	$2.00
74151	MULTIPLEXER	$1.20	2	for	$2.00
74154	DEMULTIPLEXER	$1.20	2	for	$2.00
9368	DECODER LATCH	$2.50	3	for	$6.00
1101	256 BIT MEMORY	90¢	3	for	$2.00

OPTO - electronics

FN 300	0.3 inch	COMMON CATHODE	$1.65
FN 307	0.3 inch	COMMON ANODE	$1.65
FND500	0.5 inch	COMMON CATHODE	$1.95
FND507	0.5 inch	COMMON ANODE	$1.95

POTENTIOMETER

10K	LINEAR 30mm	25¢	5	for	$1.00
20K	LINEAR 30mm	25¢	5	for	$1.00
1M	LoG 30mm	25¢	5	for	$1.00
1K	LINEAR 45mm	40¢	3	for	$1.00
470K	LOG ROTARY	35¢	4	for	$1.00
25K	DUAL LINEAR	59¢	2	for	$1.00
50K	DUAL LINEAR	59¢	2	for	$1.00
100K	DUAL LINEAR	59¢	2	for	$1.00
50K	DUAL LOG	59¢	2	for	$1.00
50K	DUAL LOG TAP	59¢	2	for	$1.00
470K	DUAL LINEAR	59¢	2	for	$1.00

HARDWARE

PC15	15 WAY,.15"PCB CONN.	30¢	4	for	$1.00
PS1	ROCKER SWITCH SPST	30¢	4	for	$1.00
RN1	240V NEON PUSH FIT	30¢	4	for	$1.00
B21	6.3V BEZEL,RED & GREEN	30¢	4	for	$1.00
MS1	MICROSWITCH SPDT	50¢	3	for	$1.00
K10	ASSORTED PLASTIC KNOBS	25¢	10	for	$2.00
DS2	2PIN DIN SOCKETS	35¢	10	for	$2.00
DP2	2PIN DIN PLUGS	25¢	10	for	$2.00
RCA5	5 WAY RCA SOCKETS	60¢	2	for	$1.00
RCA6	6WAY RCA SOCKETS	60¢	2	for	$1.00
PN216	9V BATTERY SNAP	12¢	10	for	$1.00
FH1	3AG PANEL FUSEHOLDER	60¢	10	for	$5.00
ALS	240V,3A SPST AL.TOGGLE	35¢	3	for	$1.00
PPT	PMG TOGGLE 4PDT MOM.	30¢	4	for	$1.00
TC120	12-120PF TRIMMER	25¢	5	for	$1.00

WIRES and COILS

ST45C	455kHz. IF COIL	$1.50	10	for	$9.00
S203	OSCILLATOR COIL	$1.50	10	for	$9.00
S195	RF COIL	$1.50	10	for	$9.00
FR1	FERRITE ROD COIL	$1.50	10	for	$9.00
SC0.2	.2mH CROSSOVER COIL	$1.80	3	for	$5.00
SC0.35	.35mH CROSSOVER COIL	$1.90	3	for	$5.00
SC0.5	.5mH CROSSOVER COIL	$2.00	3	for	$5.00
SC0.75	.75mH CROSSOVER COIL	$2.10	3	for	$6.00
SC1	1mH CROSSOVER COIL	$2.20	3	for	$6.00
SC1.2	1.2mH CROSSOVER	$2.30	3	for	$6.00
SC1.5	1.5mH CROSSOVER	$2.40	3	for	$7.00
SC1.75	1.75mH CROSSOVER	$2.50	3	for	$7.00
SC2	2mH CROSSOVER COIL	$2.60	3	for	$7.00
SC2.25	2.25mH CROSSOVER	$2.70	3	for	$8.00
SC2.5	2.5mH CROSSOVER	$2.80	3	for	$8.00
VPC1	1uH RF CHOKE	15¢	10	for	$1.00
VPC2	2.2uH RF CHOKE	15¢	10	for	$1.00
VPC3	3.3uH RF CHOKE	15¢	10	for	$1.00
VPC5	4.7uH RF CHOKE	15¢	10	for	$1.00
VPC7	6.8uH RF CHOKE	15¢	10	for	$1.00
VPC33	33uH RF CHOKE	15¢	10	for	$1.00
VPC100	100uH RF CHOKE	15¢	10	for	$1.00
VPC330	330uH RF CHOKE	15¢	10	for	$1.00

25gm COILS OF WIRE 18 B&S TO 40 B&S each $1.20

PC BOARD

PC64 6"x 4" LAMINATE @ 45¢ OR 10 FOR $ 4.00
PC82 8"x 2" APPROX. @ 35¢ OR 10 FOR $ 3.00

BOARDS FOR ALL PROJECTS ARE AVAILABLE, PRICES AS FOLLOWS FOR EACH BOARD :
SINGLE LAMINATE : 90¢ + 6¢ PER SQUARE INCH
SINGLE FIBREGLASS : $1.20 + 8¢ PER SQUARE INCH
DOUBLE FIBREGLASS : $1.80 + 12¢ PER SQUARE INCH

BOARDS TO YOUR OWN POSITIVE OR NEGATIVE ARTWORK AVAILABLE AT THE SAME COST PROVIDED ARTWORK IS SUITABLE FOR PHOTOGRAPHY.

BC 350

PNP GENERAL PURPOSE SMALL SIGNAL. 40 V., 100 mA. 1 WATT DISSIPATION AT 25 DEGREES CASE TEMP. DC CURRENT GAIN OF 40 TO 400. LOW SATURATION VOLTS f_T OF 200 MHz AT 20mA. MADE BY MOTOROLA.

8¢ EACH, 15 FOR $1.00, 100 FOR $6.00 AND ONLY $25.00 FOR 500.

TRANSISTORS

W04	1A	400V BRIDGE	@ $1.20	2	FOR	$ 2.00
PD8	2A	800V BRIDGE	@ $1.60	2	FOR	$ 3.00
SC141D	6A	400V THYRISTOR	@ $1.20	2	FOR	$ 2,00
MAC11-6	6A	400V THYRISTOR	@ $1.20	2	FOR	$ 2.00

AD 161	$1.60	EACH	OR	2	FOR	$ 3.00
AD 162	$1.60	EACH	OR	2	FOR	$ 3.00
AFZ 12	65¢	EACH	OR	2	FOR	$ 1.00
ASZ 18	$2.20	EACH	OR	2	FOR	$ 4.00
BC 309	9¢	EACH	OR	15	FOR	$ 1.00
BC 350	8¢	EACH	OR	15	FOR	$ 1.00
BFY 50	40¢	EACH	OR	3	FOR	$ 1.00
BFY 51	40¢	EACH	OR	3	FOR	$ 1.00
BFY 90	$1.20	EACH	OR	2	FOR	$ 2.00
BF 337	80¢	EACH	OR	3	FOR	$ 2.00
SE7055	55¢	EACH	OR	2	FOR	$ 1.00
TIP3055	80¢	EACH	OR	3	FOR	$ 2.00
2N2904	36¢	EACH	OR	3	FOR	$ 1.00
2N2904A	36¢	EACH	OR	3	FOR	$ 1.00
2N3566	36¢	EACH	OR	4	FOR	$ 1.00
2N3568	45¢	EACH	OR	3	FOR	$ 1.00
2N3638	30¢	EACH	OR	4	FOR	$ 1.00
2N4355	45¢	EACH	OR	3	FOR	$ 1.00

RESISTORS

100 OF ONE OF THE FOLLOWING HALF WATT, FIVE PER CENT RESISTORS : 100 FOR $ 1.60

1.1, 18, 22, 39, 1.5K, 47K, 68K, 100K, 150K, 180K, 220K, 270K, 330K, 470K, 560K, 680K, 1.2M, 1.5M, 2.2M, 2.7M, 3.3M, 4.7M.

POLYCARBONATE

.082 uF 100V	12¢	EACH	OR	10	FOR	$ 1.00
.047 uF 100V	12¢	EACH	OR	10	FOR	$ 1.00
.1 uF 100V	12¢	EACH	OR	10	FOR	$ 1.00
.33 uF 100V	12¢	EACH	OR	10	FOR	$ 1.00
.47 uF 100V	12¢	EACH	OR	10	FOR	$ 1.00
.56 uF 100V	12¢	EACH	OR	10	FOR	$ 1.00
.47 uF 250V	12¢	EACH	OR	10	FOR	$ 1.00
.56 uF 250V	12¢	EACH	OR	10	FOR	$ 1.00
.68 uF 250V	12¢	EACH	OR	10	FOR	$ 1.00
1 uF 100V	25¢	EACH	OR	5	FOR	$ 1.00
1.5 uF 250V	55¢	EACH	OR	2	FOR	$ 1.00

CAPACITORS

PIGTAIL TYPE

22 uF 50V	11¢	EACH	OR	10	FOR	$ 1.00
22 uF 63V	12¢	EACH	OR	10	FOR	$ 1.00
100 uF 50V	15¢	EACH	OR	8	FOR	$ 1.00
220 uF 25V	20¢	EACH	OR	6	FOR	$ 1.00
220 uF 50V	30¢	EACH	OR	4	FOR	$ 1.00
470 uF 25V	30¢	EACH	OR	4	FOR	$ 1.00
470 uF 63V	30¢	EACH	OR	4	FOR	$ 1.00
1000 uF 50V	40¢	EACH	OR	3	FOR	$ 1.00
2500 uF 25V	49¢	EACH	OR	3	FOR	$ 1.00
2500 uF 35V	65¢	EACH	OR	2	FOR	$ 1.00
3300 uF 16V	49¢	EACH	OR	3	FOR	$ 1.00

PC BOARD TYPE

22 uF 50V	11¢	EACH	OR	10	FOR	$ 1.00
47 uF 50V	15¢	EACH	OR	8	FOR	$ 1.00
330 uF 50V	30¢	EACH	OR	4	FOR	$ 1.00
470 uF 50V	30¢	EACH	OR	4	FOR	$ 1.00
1000 uF 35V	40¢	EACH	OR	3	FOR	$ 1.00

POLYSTYRENE

120 pF	15¢	EACH	OR	10	FOR	$ 1.00
270 pF	15¢	EACH	OR	10	FOR	$ 1.00
470 pF	15¢	EACH	OR	10	FOR	$ 1.00
820 pF	15¢	EACH	OR	10	FOR	$ 1.00
.0047 uF	20¢	EACH	OR	8	FOR	$ 1.00

TAG TANTS

3.3 uF 35V	25¢	EACH	OR	5	FOR	$ 1.00
33 uF 10V	25¢	EACH	OR	5	FOR	$ 1.00
47 uF 6V	25¢	EACH	OR	5	FOR	$ 1.00
68 uF 3V	25¢	EACH	OR	5	FOR	$ 1.00
100 uF 3V	25¢	EACH	OR	5	FOR	$ 1.00

ZENERS

400mW ZENERS IN THE FOLLOWING VALUES :

8.2V, 12V, 22V, 24V, 27V, 30V,
18¢ EACH OR 7 FOR $ 1.00

500mW ZENERS, MOTOROLA BRAND :

8.2V, 12V, 30V, 100 FOR $10.00

SE 7055

NPN HIGH VOLTAGE VIDEO OUTPUT TRANSISTOR, 220V., MAXIMUM DISSIPATION OF 7 WATT AT A CASE TEMP. OF 25 DEGREES. DC CURRENT GAIN OF 20 TO 75. f_T OF 40 TO 50 MHz. MANUFACTURED BY FAIRCHILD.

55¢ EACH, 10 FOR $5.00, 100 FOR $40.00 AND ONLY $90.00 FOR 300.

VALVES

ZM1000 NIXIE REDOUT TUBES : 10 FOR $ 5.00
12AU7 VALVES 10 FOR $ 3.00

guitar amp ETI 413 69.50

Complete kit including metalwork. Rugged quality amplifier for public address and guitar use. We can supply this kit with preamplifier.....$12.00

quad amp 99.50

Complete kit including metalwork and front panel Cover is not included. Amplifier modules allow a simple construction with high performance. Uses IC designed for SQ decoder. Wooden sleeve $12.50

ETI 420

stereo amp 99.50

ETI 422

Complete kit including metalwork and front panel A high power, versatile HIFI amplifier. Reliable low distortion high power. Limited quantity only available at this price. Cover is not included. Wooden sleeve.............................$12.00

reverberation 29.50

ETI 424

Complete kit including metalwork and front panel Cover is not included. Origonal spring supplied. Easy to construct. Wooden sleeve..........$12.00

$5.00 FREE PACK SUPPLIED WITH ORDER OVER $25.00

THIS PACK OF PARTS CONSISTS OF RESISTORS, PLUGS, TRANSISTORS, CAPACITORS AND OTHER ITEMS, MANY OF WHICH ARE ADVERTISED ON THIS PAGE. VALUE IS OVER FIVE DOLLARS AT USUAL PRICES. VALID TILL 30-9-77

EA CDI 18.50

Complete kit with prewound secondary coil. High quality components and undrilled metalwork. Buy now for easy winter starting and running.

EA SQ 29.00

This is the three I.C, SQ decoder kit as featured in EA February 1977. Complete with board, rotary pots and IC's. No case or power supply. This is a very popular kit. See below for conversion kit.

EA SQS 22.00

As above but excluding MC1312 and associated bits Convert your existing simple SQ system to full SQ with wave matching logic. Outstanding performance

ALL ITEMS IN THIS BLOCK ARE AVAILABLE AT THESE PRICES WHILE STOCK LAST OR UNTIL 30/9/77

Postal address
BKX Electronics Supply Service,
PO Box 787, Potts Point,
Sydney, 2010.

MAIL ORDER........minimum....$8.00.
Pack and post....free in Australia.
Catalogue....90¢....40¢ with order.
Telephone enquiries..(02) 358 2420.

PROJECT ELECTRONICS KITS

ALL THESE KITS INCLUDE BATTERIES IF 3, 6 OR 9 V. A FOUR INCH EIGHT OHM SPEAKER SUITABLE FOR SCREW MOUNTING, PC BOARD IF ILLUSTRATED IN THE PROJECT BOOK, AND PARTS AS PER PARTS LIST.

PROJECT ELECTRONICS FROM ETI. (With P&P) $ 5.00

ETI 041	CONTINUITY TESTER	$ 4.95
ETI 042	SOIL MOISTURE INDICATOR	$ 2.95
ETI 043	HEADS OR TAILS	$ 3.95
ETI 044	TWO TONE DOORBELL	$ 6.95
ETI 045	500 SECOND TIMER	$ 5.95
ETI 047	MORSE PRACTICE SET	$ 7.95
ETI 511	BATTERY SAVER	$ 3.95
ETI 048	BUZZ BOARD	$ 5.95
ETI 061	BASIC AMPLIFIER	$ 6.95
ETI 062	SIMPLE AM TUNER	$ 9.95
ETI 063	ELECTRONIC BONGOS	$ 4.95
ETI 064	SIMPLE INTERCOM	$ 4.95
	(ONE SPEAKER,MOMENTRY TOGGLE SUPPLIED)	
ETI 066	TEMPERATURE ALARM	$ 6.95
ETI 067	SINGING MOISTURE - METER	$ 5.95
ETI 071	TAPE NOIS LIMITER	$ 3.95
ETI 072	TWO - OCTAVE ORGAN	$ 9.95
ETI 068	LED DICE	$ 6.95
ETI 081	TACHO	$ 9.95
ETI 085	OVER - REV ALARM	$ 5.59
ETI 085	OVER - REV ALARM	$ 5.95
ETI 528	INTRUDER ALARM	$ 9.95
ETI 084	CAR ALARM	$ 8.95
ETI 083	TRAIN CONTROLLER	$17.95
ETI 086	FM ANTENNA	$
ETI 087	OVER LED	$ 3.95
ETI 065	ELECTRONIC SIREN	$12.95

TEST GEAR KITS

TEST GEAR FROM ETI (WITH P&P) $ 3.50

ETI 438	AUDIO LEVEL METER	$13.50
ETI 116	IMPEDANCE METER	$47.50
ETI 128	AUDIO MILLIVOLTMETER	$49.50
ETI 533	DIGITAL DISPLAY	$19.50
ETI 118	SIMPLE FREQUENCY COUNTER	$32.50
ETI 133	PHASE METER (with case)	$15.50
ETI 130	TEMPERATURE METER	$12.50
ETI 102	AUDIO SIGNAL GENERATOR	$29.50
ETI 441	AUDIO NOISE GENERATOR	$ 9.50
ETI 124	TONE BURST GENERATOR	$21.50
ETI 704	CROSS HATCH AND DOT GENERATOR	$17.50
ETI 129	RF SIGNAL GENERATOR	$29.50
ETI 706	MARKER GENERATOR	$29.50
ETI 120	LOGIC PROBE	$13,50
ETI 121	LOGIC PULSER	$11.50
ETI 122	LOGIC TESTER	$59.50
ETI 123	SIMPLE CMOS TESTER	$24.50
ETI 222	TRANSISTOR TESTER	$17.50
ETI 115	LINEAR IC TESTER	$21.50
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Electronics Today International — and its sister publications, Hi-Fi Review, have arranged to supply readers with these superb modular record racks, made by Fisher Engineering.
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The rack construction is totally modular so racks may be assembled however you please. Thus if you buy three basic racks you have in effect 12 sections. You can put these together as 4 threes, 3 fours, 2 sixes or one long rack holding 120 records.
The racks are made of massively thick and heavy (each basic rack weighs 3/4 kilo!) transparent plastic which is lightly tinted in a choice of bronze, smoke grey, amber or purple.
These racks have only recently been released and normally sell for between $6.50 — $7.00 or so. We have however been able to arrange for our readers to purchase them at massive discounts.
We are delighted to be able to make this offer. We unequivocably recommend them as one of the best solutions to record storage we've yet seen. They are a first class engineering product. Virtually everyone on our staff who has seen them wants some. At the 'two or more' prices they're a steal — we'll almost guarantee that everyone who places an order will quickly buy a lot more!

This is one basic rack — each of the four sections comfortably holds 10 full size LPs

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ETI's COMPUTER SECTION

NEWS

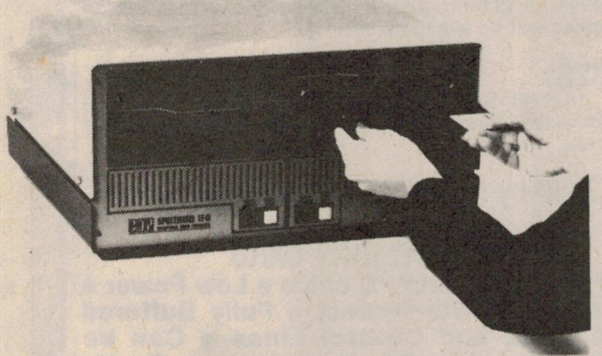
SWTPC Available

After the large number of S-100, 8080-based systems that are available in the States, probably the most popular hobby computer system is Southwest Technical Product Corp's MP-68. This is based on the M6800 microprocessor, and uses the Motorola MIKbug monitor program to neatly avoid the complications and expense of a front panel. The MP-68 is probably the least expensive computer around, and so has become very popular. Another way of keeping the cost down has been the use of Molex connectors similar to those used in the ETI VDU design. Although the SWTPC boards are smaller and not as 'standardised' as the S-100 types, other manufacturers have caught on to its bus layout and are producing boards for what has been christened the 'SS-50' bus.

SWTPC also produce a range of peripherals, including two VDU designs, and an excellent KC cassette interface, the AC-30, which can control two cassette recorders. Anyway, the reason we're telling you all this is that SWTPC, or 'Sweatpack', as it is affectionately termed by devotees, is now available in Australia from *Paris Radio Electronics, 7a Burton Street, Darlinghurst, NSW.*

IIL 4K Static RAM

Texas Instruments have announced a 4K bit static RAM built using integrated injection logic. The S400 will retain data even when the supply rail sinks to 2 Volts, and dissipates only 500 mW and 25 mW on standby.



COMPUTEX SPECTRUM-11

New from *D.D. Webster Electronics Pty. Ltd.* of *1326 Ferntree Gully Road, Scoresby, VIC 3179* is the Computex Spectrum-11 microcomputer. This is virtually a minicomputer which software consultancy houses can use to fulfill their clients' requirements without getting involved in hardware design.

The CPU in this machine is the DEC LSI-11, which executes the instruction set of the sixteen-bit PDP-11 mini. This CPU was chosen after a long, cool look at available microprocessors.

The Webster 'Small Commercial System' was to be as follows: CPU, 32 Kbytes (optionally 64Kbytes) of MOS memory, 256 word PROM bootstrap, one to four floppy disks (up to 1.26 Mbytes on line), two serial line interfaces, line printer interface, card reader interface, and several spare backplane slots (LSI-11 bus). There aren't many micros around that can support that kind of system.

The advantage of the LSI-11 lies in the number of languages (FORTRAN, BASIC, multi-user BASIC, and FOCAL) that it can support, and the sheer volume of software available. This is much better than the support available for other micros.

The Spectrum-11 incorporates the latest LSI components, such as 16K dynamic RAMs, the Western Digital FD1771 Floppy Disk Controller chip, and lots of low power Schottky MSI to help with power consumption and cooling.

But the heart of the system is a 32-bit wide 512 word microprogrammed controller which controls the whole system including clock generation and overseeing DMA and bus control. This processor does most of the housekeeping and releases the main processor to do useful work.

The Spectrum-11 comes in four versions: with 1 or 2 drives, and with 32K or 64K of memory. It is intended for table-top mounting and is a well-proportioned 8¾" x 19" x 20" in size. D.D. Webster believes this is a new industry record for packing density. Price is from $6500.

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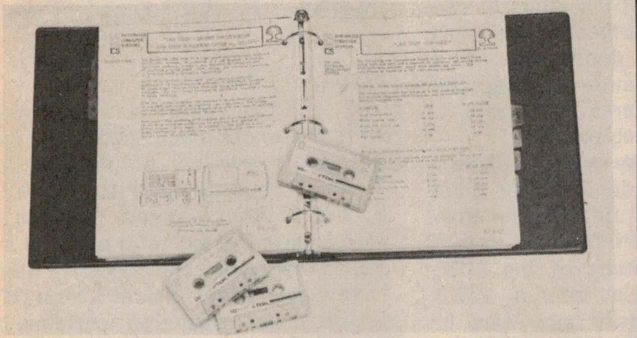

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MORROW'S FRONT PANEL

Super CPU forms heart of system — by Kevin Barnes

WHEN THE TIME COMES to make the decision of which computer to buy there are a number of questions worth asking yourself. They are, do I know what I want from a computer?, will I want to expand my system later? and if so, can this be done with my chosen system? Lastly, one of the most important questions is am I getting value for my money?

An interesting answer to some of these questions is the Morrow's Micro Stuff front panel, which we recently had a chance to try out. A recent arrival in Australia, these kits are designed and manufactured in the States, and are now being imported and sold locally by Automation Statham at Bankstown.

A first thought on taking delivery was: 'Who wants a front panel, I use a terminal?', but closer inspection revealed that this was no ordinary front panel. In fact it's really a combination CPU/front panel, a sort of self-aware CPU. The CPU, as befits an S100 board, is an 8080A microprocessor chip, with some useful intelligence supplied by dedicated RAM and ROM. At this point we realized that this is a quite sophisticated board and requires a lot of attention to detail in order to fully appreciate it.

Firstly, what do you get for your money when you buy a Morrow front panel. It's a single PC board on which are mounted a 12 digit keyboard, ten seven-segment displays, and enough logic to implement an S100 CPU.

INTERACTIVE PANEL

The keyboard and display are interfaced with the CPU so that the operator can control and communicate with his computer. This is done through a monitor program which enables the display and even alteration of data in memory or the CPU registers.

Conversation between the operator and the monitor is done in the octal system. This is based on 8 rather than 10 or 16. The reason for this is that the internal microcoding of the 8080 breaks bytes bit-wise into a 2/3/3 format, which is easily expressed in octal. This also gives the programmer a mnemonic aid when hand coding programs.

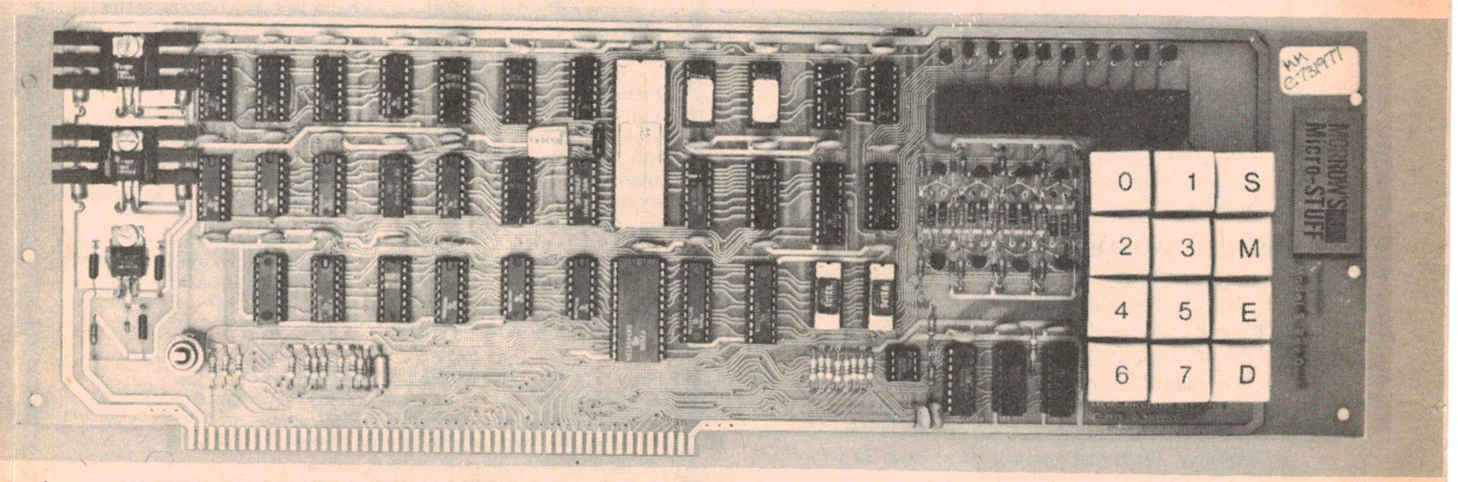
Expressing 16 bit addresses in octal is done in the 2/3/3/2/3/3 grouping rather than the 1/3/3/3/3/3 format. This is because the 16 bits are stored in memory as two 8-bit words and it's easier to break up byte-oriented octal.

The front panel remembers and displays the last six digits to be entered via the keyboard. They are displayed on the six leftmost LED displays and as each digit is keyed, it is left-shifted into the display. After a function key is pressed and its operation is completed, the digit memory is initialized to zero in readiness for the next input. If an error is made in digit entry the operator can simply re-key the required string. Note that while the most recent six digits are used for 16 bit addresses or data, only three digits are used for 8 bit addresses or data. This can save up to three key-strokes if you make a mistake.

WHAT IT DOES

The operator controls the computer with the function keys that make up the right-most column of the keyboard. There are four keys with the labels S, M, E, and D. Briefly stated, the S key can stop a currently executin program single step through through a program or make it run at a selectable rate from 10 ms to 2.5 s per instruction, certainly slow enough for the operator to follow what's going on.

The M key starts programs running and determines the front panel's mode of operation. The E key is used to examine data in memory locations, I/O ports, and the CPU registers while the D key stores data into them.



For more detailed information see the examples on page 103.

Effectively, the monitor has two operational modes. The first is the 'controlled halt' mode and works like this: Whenever the 8080 encounters a halt instruction in the program special hardware forces the it to execute a NOP or no-operation instruction, and then passes control to the front panel monitor which saves the contents of the contents of the 8080 registers for later examination. This method ensures that the operator never loses control of the

computer as he would if the halt instruction was executed. Any halt put into a program then becomes a breakpoint. Intelligent use of breakpoints is a powerful debugging tool.

Another effective debugging process is to single or slowstep through a program at a controlled rate. This is the second operational mode of the Morrow front panel. In this mode, it can be made to selectively displat the contents of any 8080 internal register, memory location, or I/O port. For example monitoring the program counter tells you what part of the program the computer is executing while monitoring an I/O port lets you know what's happening to other parts of the system.

That's to say, as your program modifies a particular memory location or register, that change can be shown on the display as it occurs.

GETTING IT GOING

The first thing to do is to assemble the board, as it is supplied as a kit of parts. We had no difficulty with this, as the board is well made and has a solder mask to prevent flow between tracks. On power-up we had a slight problem with the display, which we tracked down to a faulty diode and soon had the board running properly.

Once it's assembled, a few other bits and pieces are required. The board needs a power supply with the following specifications: +8 V at 1.5 A approx., +18 V at 0.2 A and −18 V at 0.02 A. Also required is some memory to store programs, as, although the Morrow has some RAM on it, it is dedicated to the monitor and not available to the user. The extra RAM should be S100 compatible, and to connect it to the front panel, two 100-pin edge connectors and a piece of mother board are required. Alternatively, the sockets may be joined using wire-wrap techniques.

The completed board forms a sophisticated CPU, and with the addition of some RAM, forms a minimum system. The board is extremely well designed, both mechanically and electrically, and it is recommended that it be returned to the agents for repair.

The documentation supplied with the kit isn't the world's best, but this isn't a Heathkit and experienced constructors should have no difficulty. Next month we shall relate some of our experiences in putting a system together, and also give constructional details for a computer power supply suitable for the S100 bus.

KEY FUNCTIONS

0 – 7 These are data keys which allow the operator to enter data into the computer. There are eight keys, just the number required to specify any digit in the octal number system used by the Morrow Front Panel.

M This is the mode key and is used to set the Morrow monitor program into one of its four modes. They are called the 0, 1, 2 and 3 modes. To change modes the operator first keys in the mode number (0 – 3) and then presses the M key.

Each mode allows the operator to be involved with different parts of the system. Modes 0 and 3 deal with memory, mode 1 with the 8080 internal registers and mode 2 with I/O ports.

Once a particular mode has been selected the three remaining function keys can be used by the operator to perform the required tasks.

E Called the Examinr key, it lets the operator examine data within the system. Notice that the phrase computer system was used and not just CPU/Front Panel. This is correct because depending on what mode you have selected, it is possible to examine memory locations and I/O ports with the E key as well as the internal registers of the 8080.

Within each mode there are two ways of using the E key. The first way is to enter a nomber from the 0 – 7 keys and then press E. This way the monitor uses the entered number as the address of a location to be examined.

The second is to press E without inputting anumber. This way still examines data in the system but gets the address of what it should display by adding one to the previous address that was examined. This means that in modes 0 and 3 the monitor displays the contents of sequential memory locations and in mode 1 the contents of the 8080 registers. In mode 2 the automatic incrementing is left unimplemented.

These features make checking programs quick and convenient. For example assume that the monitor is in mode 0 and we want to find out what's in memory locations 100 through 103 (inthis example, 11, 22, 33, 44):

KEYSTROKES	DISPLAY
100 E	000 100 011
E	000 101 022
E	000 102 033
E	000 103 044

D Is best described as the deposit key and is used to store the value you want in selected memory locations, 8080 registers or I/O ports depending on the current mode selected.

The D key is used by first inputting an address on the 0 – 7 keys and pressing the E key. This sets up an address to be acted on. Next the data to be stored is input and the D key is pressed; that data is now stored. To store into the next memory location or 8080 register all you need do is enter the data and press D; the monitor automatically increments the address where the data will be stored. In mode 2 (I/O mode) the automatic incrementing is left unimplemented.

S Is called the step key because it lets the computer step through the program one instruction at a time. There are in fact two ways of using the S key. In the first method an instruction is executed each time the key is pressed. In the the second way, the operator keys in a number before pressing S. The monitor takes note of the number and begins executing the program instruction by instruction without waiting for additional operation of the S key; however it does insert a time delay between each instruction execution, the length of which is proportional to the number entered before the key was pressed. Compared to humans, computers are very fast and so this induced time delay slows the computer down to where the mind can follow what's happening. This feature is handy for debugging both software and hardware problems.

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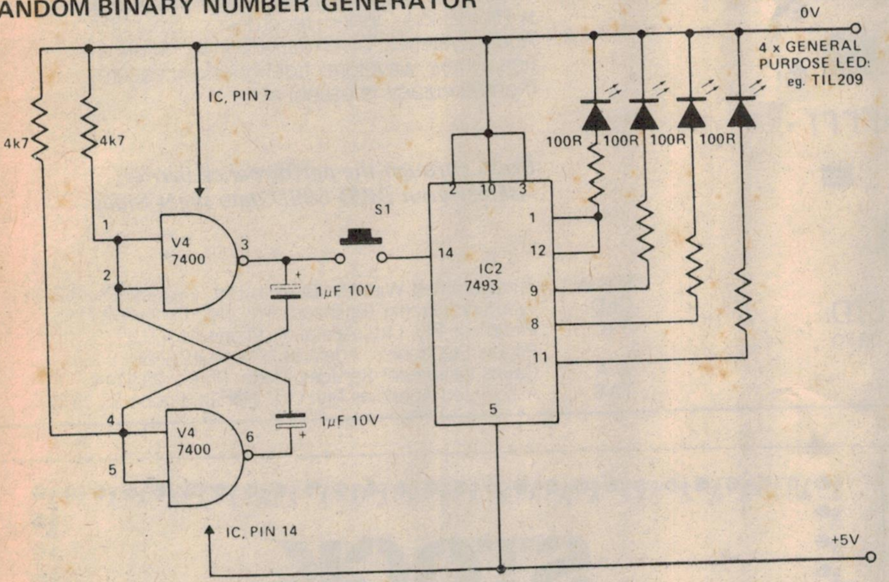
Ideas for experimenters

These pages are intended primarily as a source of ideas. As far as reasonably possible all material has been checked for feasibility, component availability etc, but the circuits have not necessarily been built and tested in our laboratory. Because of the nature of the information in this section we cannot enter into any correspondence about any of the circuits, nor can we produce constructional details.
Electronics Today is always seeking material for these pages. All published material is paid for – generally at a rate of $5 to $7 per item.

RANDOM BINARY NUMBER GENERATOR



The circuit shown is a random indicator providing an output from one of 16 states.

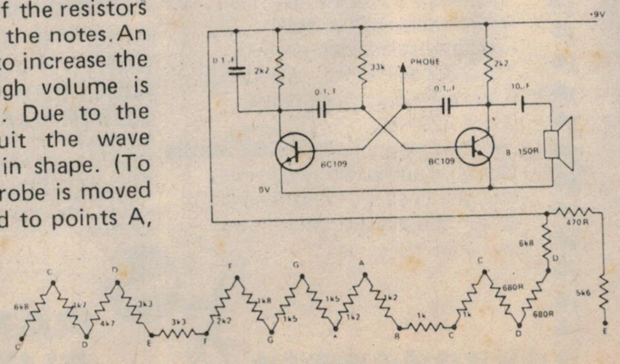
It consists of a BCD counter driven by a multivibrator. As the multivibrator's frequency is relatively high, one can say that the output from the counter, IC2, is random.

IC2 has a fan-out capability of 10 normal TTL loads and so can operate the LED displays directly. The four 100 ohm resistors are used to limit the current through the LEDS and so prevent them and IC2 from being damaged.

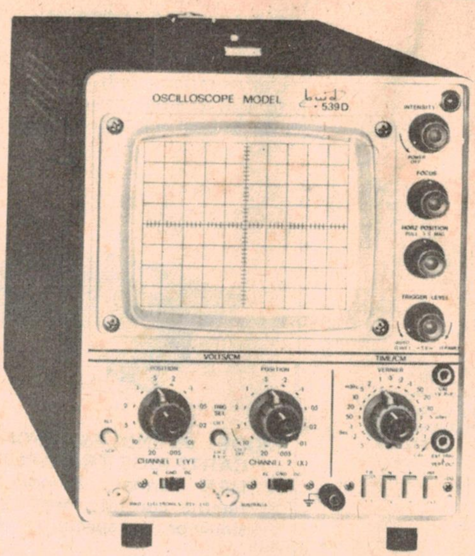
The unit is operated by depressing S1, which will cause the LEDs to flash, and when S1 is subsequently released the last number held in the counter will be displayed in BCD (Binary Coded Decimal) form.

SIMPLE ORGAN

The tone generator is an astable multivibrator with one of the resistors being variable to change the notes. An amplifier could be used to increase the volume, but quite a high volume is attained by the astable. Due to the simplicity of the circuit the wave form is rather irregular in shape. (To produce the note, the probe is moved across metal strips wired to points A, B, C etc).



25 MHz Bandwidth



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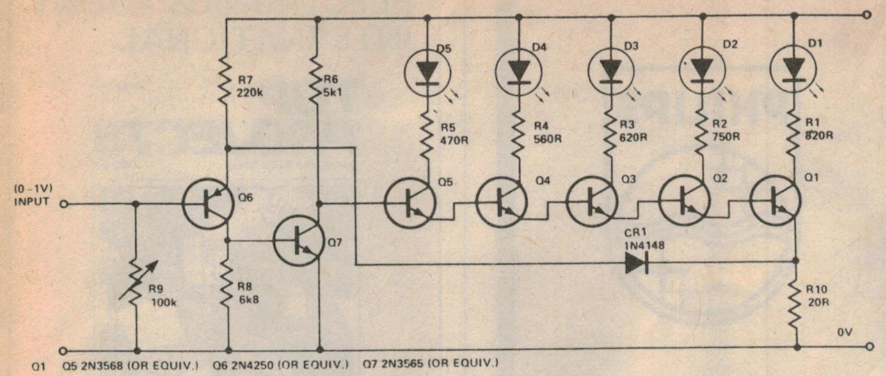
Ideas for experimenters



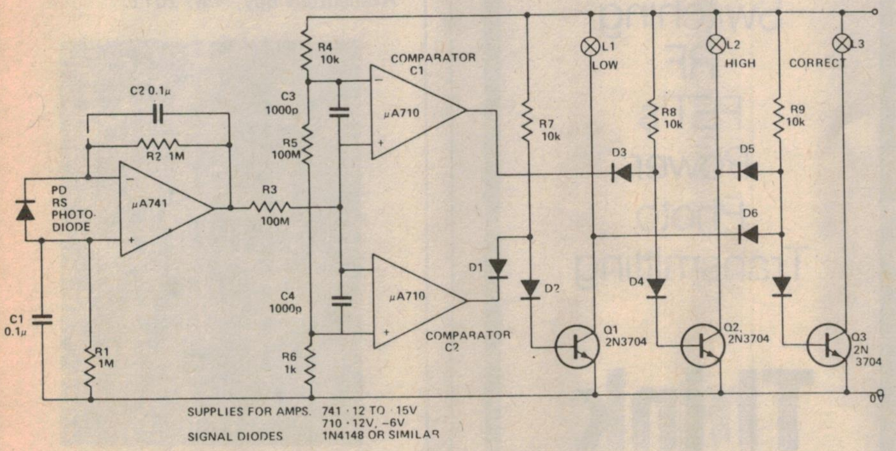
BARGRAPH DISPLAY

A bargraph display is a useful medium for seeing a monitored variable. Where low resolution (5 to 10 segments) is sufficient the display can be built with LED's and a few transistors.

With the 5 segment system shown, transistors Q1 to Q5 saturate successively as the input signal increases from zero. The resulting currents drive LEDs D1 to D5. As each transistor turns on, its emitter current flows through R10. Transistors Q6 and Q7 as well as CR1 and associated resistors, comprise a feedback amplifier that forces the voltage across R10 to equal the inputs voltage. This causes the display to 'deflect' linearly.

For R10 = 20R and a current of 100mA per LED, the resolution is 200mV and the full scale input equals 1V (for five LED's). Diode CR1 cancels the V_{BE} offset of Q6. Resistors R1 through R5 control the LED currents. The voltage across R3 for example is 10V minus 1.5V (two transistors $V_{BE's}$) minus 0.6V (30mA – R10). Since V_{CE} (SAT) of Q3 is negligable at 10mA, 6.4V must be dropped.

i.e. $R3 = \frac{6.4V}{.010A} = 640R$. 620R being the nearest standard value.



LIGHT LEVEL INDICATOR

When conducting optical experiments or calibrating photocells, it may be necessary to set a known light level each time before the experiment is performed. The circuit provides a simple means of setting a light level to a particular value.

A silicon planar photodiode, strategically placed in the optical system, generates a photocurrent proportional to the incident illumination which is fed to the input of an op amp connected as a current amplifier. The output is thus the equivalent photocurrent developed across a 2Mohm resistor.

Two comparators are used to compare the output voltage with a fixed reference set by a potential divider chain. Comparator 2 is set at nominally 1V and Comparator 1 at 1.1V.

The amplifier output is fed via R3 to the inverting input of comparator 2. When the output is below 1V, the output of comparator 2 is positive

(Continued on page 111).

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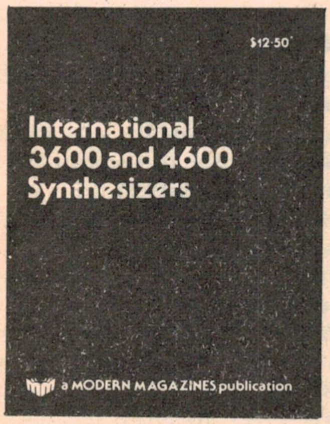

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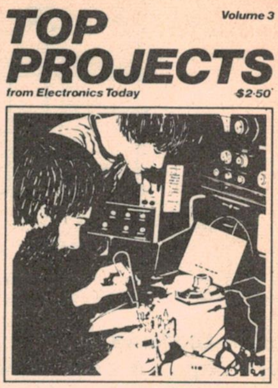

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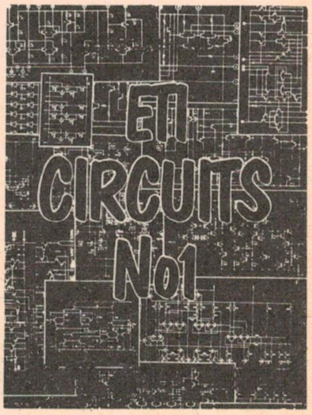

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which enables the current in R7 to turn on Q1, lighting lamp 1 indicating "Too Low". When the output of the amplifier is above 1.1V the output of comparator C1 will be positive, enabling current in R8 to turn on Q2 and lighting lamp L2 indicating "Too High". If the amplifier output is between the two thresholds, both comparator outputs will be low, both lamps will be off, and the current in R9 will be enabled to Q3 and L3 will light giving the green indication "Correct".

Changing the values of R1 and R2 alters the basic sensitivity of the system, C1 and C2 provide decoupling of noise pick up for remote direction or small content of AC lighting and R3, C3, and C4 minimise instability in the comparators as they pass through their linear region.

Values in the diagram shown give an acceptance band of 10%. Reducing the value of R4 to 50 ohms reduces the pass band to 5%. For closer bands, higher gain comparators may be used (eg. µA734 or LM311), but light levels closer than this are rarely necessary.

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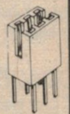

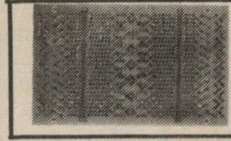

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7438	.25	74107	.37	74190	1.15
7440	.15	74121	.38	74191	1.25
7441	.89	74122	.38	74192	.95
7442	.59	74123	.65	74193	.85
7443	.73	74125	.54	74194	1.25
7444	.73	74126	.58	74195	.74
7445	.73	74132	.89	74916	1.25
7446	.81	74141	1.04	74197	.73
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4002A	.25	4021A	1.18	4069A	.44
4006A	1.35	4022A	.94	4071A	.26
4007A	.26	4023A	.25	4072A	.35
4008A	1.52	4024A	.89	4073A	.39
4009A	.57	4025A	.25	4075A	.39
4010A	.54	4027A	.59	4078A	.39
4011A	.29	4028A	.98	4082A	.35
4012A	.25	4030A	.44	4518A	1.56
4013A	.45	4035A	1.27	4528A	1.56
4014A	1.27	4040A	1.39	4585A	2.10
4015A	1.27	4042A	1.47		
4016A	.48	4049A	.59		
4017A	1.01	4050A	.59		

74C00	.19	74C74	1.04	74C162	2.49
74C02	.26	74C76	1.34	74C163	2.66
74C04	.44	74C107	1.13	74C164	2.66
74C08	.68	74C151	2.62	74C173	2.22
74C10	.35	74C154	3.15	74C195	2.26
74C20	.35	74C157	1.76	80C95	1.15
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74C73	1.04	74C161	2.49		

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RLC-201	RED DIFF. CURRENT REG. CONST. BRIGHTNESS 4.5- .190"	.25
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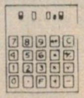

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